NVIDIA RTX 3080 TI
A paper launch or the new GPU king? PG. 76

COOLING HACKS
Take your build to the next level PG. 62

PIXEL PERFECT
An in-depth look at the screens of tomorrow PG. 40

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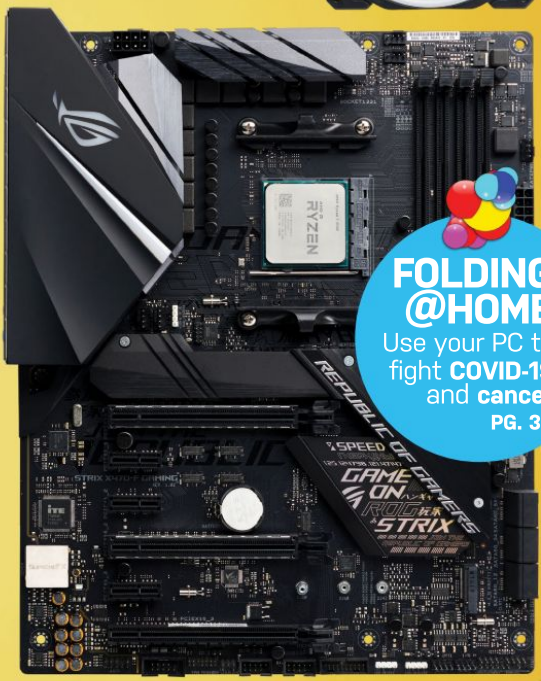
BUILDER'S GUIDE

38 pro tips & tricks to turn your system into a dream machine



FOLDING @HOME
Use your PC to fight **COVID-19** and **cancer** PG. 30

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inside

AUGUST 2021

SUBSCRIBE TODAY!
PG. 38

QUICKSTART

10 THE NEWS
AMD starts to stack; new Windows; Apple strengthens privacy; more.

13 TECH TALK
A DLSS competitor that works on any GPU.

16 INTERVIEW
Sergio Perez Conesa discusses how Folding@home helps his work.

It's back to the future with our retro-style build.

R&D

55 HOW TO
Create surreal spherical art; build a better liquid-cooled setup; improve video calls in Nvidia Broadcast; more.

56 AUTOPSY
Will our teardown of the new Apple M1 iMac bear fruit?

68 BUILD IT
A step-by-step guide to our pseudo retro conversion.

LETTERS

18 DOCTOR

94 COMMENTS

IN THE LAB

76 NVIDIA GEFORCE RTX 3080 TI

78 ACER PREDATOR ORION 3000

87 RAZER OPUS

89 STEELSERIES RIVAL 5

30 CORONAVIRUS VS. THE GIANT COMPUTER
How Folding@home took time off to tackle a pandemic.

40 THE SCREENS OF TOMORROW
Move over gamers, it's time for productivity panels to get in on the upgrades.

50 A PARENT'S GUIDE TO PROGRAMMING
A look at which languages to consider to help your kids get a head start in coding.

90 RESIDENT EVIL VILLAGE

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BUILDING FOR TOMORROW

IT'S DIFFICULT FOR US to really talk about building PCs right now, because there's very little hardware out there available for your average build. Nonetheless, it's important to stay on top of things, particularly in the world of custom rigs, and it's something we've adamantly supported since the very conception of *Maximum PC*, and its predecessor, *boot* magazine.

Like a hobbyist mechanic and a classic car, a woodworker with their workbench, and an amateur astronomer and their telescope, building, maintaining, and tinkering with your own machine is a time-honored rite of passage for anyone and everyone interested in the computing world.

This issue, we're revisiting an old favorite, with an updated look at the ultimate builder's guide, with tips, tweaks, and tricks to help take your next build, or even your current one, to the next level. Written by our two staff writers and overseen by my good self, there's a multitude of perspectives in there, and plenty to sate every type of PC builder.

If you're just sick and tired of builds, however, and the hardware drought is driving you mad, don't worry, because we've got you covered with some awesome features elsewhere, too. Ian takes a look at Folding@home this month; in particular, how it came into play during the coronavirus pandemic and became the world's first exascale networked supercomputer. Jeremy's also come in to give us an updated look at screen tech for the coming year, and our friends at *Linux Format* give us the lowdown on how to get your kids (or even yourself, for that matter) into coding. Which will inevitably be just as vital to future generations as English and math are today.

On top of that, we've got a ton of tutorials for you, and perhaps the world's weirdest PC build this issue, inside the bizarre yet impressively stylish Raijintek Pan Slim. And, of course, we have a bevy of reviews, too, including everything from the Nvidia RTX 3080 Ti to the latest Asus ROG Zephyrus laptop, plus an interesting look at some neat peripherals.

There's a heck of a lot in this issue, and we've got even more epic features lined up over the coming months, covering everything from the potential for a technological apocalypse to quantum computing round-ups, AI revolutions, and more.

Come for the builds, stay for the insanely in-depth features. I truly hope you enjoy the latest issue of *Maximum PC*. Stay safe out there, and I look forward to seeing you next time.

Zak is Maximum PC*'s editor-in-chief and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: editor@maximumpc.com

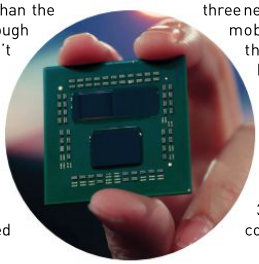
THE NEWS

AMD Starts to Stack

And triples the L3 cache in the process

WHEN AMD attends an event to show off its new gear, you won't come away disappointed. At this year's Computex trade show in Taiwan, AMD's CEO, Lisa Su, showed us what she called "the next big step forward" in advanced chip packaging. AMD has been working with TSMC and its 3DFabric technology to combine chiplet packaging with die stacking to create a 3D chiplet architecture. The first application of this will be a 3D vertical cache, stacking memory chips directly over the processing units.

We were then treated to a glimpse of a prototype chip, a Ryzen 9 5900X with 64MB 7nm SRAM chips stacked on to each core complex, tripling the amount of L3 cache to 192MB. There is over 2TB/s of bandwidth connecting this new cache, faster than the L1 cache, although latency won't be anywhere close. The two silicon wafers use a direct copper-to-copper bond, with no micro-bumps (as used in Intel's solution). AMD has dubbed this V-Cache.



This is a massive amount of L3 cache to put on a chip, and AMD used games to show what a difference it makes. Pitching the prototype against a standard chip gave an average performance bump of 15 percent. That's the equivalent of a new core architecture's IPC gain. Even better: "We'll be ready to start production on our highest-end products with 3D chiplets by the end of this year." This means EYPC chips first, but AMD also assured us that its road to 5nm is "right on track." This leaves us with the tantalizing prospect of the Zen 4 core architecture on a 5nm process using wedges of 3D stacked cache all arriving at once next year, giving a double performance hit in one go.

We also got a chip launch: three new 6000-series mobile GPUs, the Radeon RX 6600M, 6700M, and 6800M. All based on the RDNA2 architecture, with 28, 36, and 40 compute units respectively. The 6800M is AMD's most powerful mobile GPU yet, at 2.3GHz and with up to 12GB of GDDR6 and 96MB of Infinity cache. AMD's charts pitch it against the Nvidia RTX 3070 and 3080 mobile versions. It wins, of course, but only by a frame or three.

> This Ryzen 9 has a 64MB cache chip bonded directly over one of the CCDs.

The company also has a new initiative called AMD Advantage, a set of parameters compiled by AMD and top laptop manufacturers. There is an extensive set of demands to qualify, including 100fps at 1080p, low-latency 144Hz displays, comprehensive thermal management, acoustics requirements, and over 10 hours of video playback on one charge. It's all designed to ensure that AMD's wares get a chance to shine. The first fruits of the initiative have landed, including the storming Asus ROG Strix G15 Advantage Edition, which uses a Ryzen 9 5900HX coupled to the RX 6800M for maximum thrills, and not especially cheap ones, either; it costs $1,650, but offers a lot of bang for those bucks. AMD is rapidly closing in on the high-end gaming laptop market.

And that's not all. We got a pair of new desktop APUs, the Ryzen 7 5700G and Ryzen 5 5600G to replace the elderly 3000-series APUs. They are Zen 3 parts, and thankfully AMD has unified the naming conventions now. The eight-core 5700G runs at 4.6GHz and carries 16MB of L3 cache. The 5600G has six cores, a clock of 4.4GHz, and a 16MB cache. The Vega-based graphics isn't the strongest, so it will be casual gaming only. The chips sell for $359 and $259 respectively—a trifle high, perhaps.

Lastly, we also got a look at AMD's FidelityFX Super Resolution (FSR), an upscaling and anti-aliasing technology. It's a response to Nvidia's DLSS, which uses AI to upscale; FSR doesn't use AI, which makes it easy to implement across all hardware platforms. However it does need game support, which will hold it back a little. The demo showed frame rates jumping by three times, but other AMD sources say double. We've been waiting a while for this—it was first announced over a year ago. The good news is that you don't need AI hardware, so older Radeons benefit, the downside is the results aren't as sophisticated as you might hope. Early impressions show blurry outlines and a loss of definition in textures. This is reminiscent of the first iteration of DLSS, so let's hope FSR can be worked on, too. You can read more about FSR on page 13.

That's it, folks. AMD is still releasing chips at a hectic rate, and all this activity is slowly bringing the market around, too. The latest figures from Steam show the split has changed from 80/20 Intel/AMD in 2019 to 70/30 early this year, with AMD gaining over 7 percent in the last year. And the train shows no sign of slowing down. **–CL**

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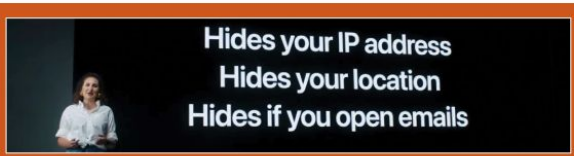
NEW WINDOWS VERSION DUE

WINDOWS 10 GETS AN END DATE, TOO

BY THE TIME YOU READ THIS, Microsoft will have made a major announcement on the next version of Windows; however, we've already seen a leaked beta version. There's an updated UI, complete with the expected updates from the canceled Win 10X. There are centered app icons, like a Mac, although you can change it back. There's a simplified Start menu, and a lot more rounded corners. Intriguingly, an icon labeled "Widget" appears (it's back, hurrah). There's a smart new Snap feature, to quickly resize windows to a set of predefined arrangements. The Xbox app is also now integrated into the OS. Excited? Probably not; from what we've seen, it appears to be a visual refresh, with some tweaking around the edges. It's due to launch later this year. Meanwhile, Windows 10 has been assigned a death date—support is set to end October 14, 2025. **–CL**



APPLE STRENGTHENS PRIVACY

Masked IPs, a VPN, and more

APPLE, keen to be seen as a protector of privacy, has introduced new security features. We have App Privacy Report, a new section in Settings on iOS that shows what each app has requested access to and where your data has been shared. Also, Siri will no longer send your voice off to a server for processing, but do it locally (minus web searches). Safari will block your IP address, as will Apple Mail, so marketers can't track where emails go. Apple's iCloud Plus subscribers also get Private Relay, an encrypted VPN of sorts, as well as Hide My Email, which enables you to create random email addresses when subscribing to online services, so you don't reveal your direct address. Neat. Cynicism aside, this is a solid set of features on keeping tabs on who has your data. The only fly in the ointment is China, where Apple has dropped Private Relay. Such privacy is illegal in China without a government license. It's also where Apple makes 15 percent of its revenue, and assembles its iPhones. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

RANSOM RECOVERED
The FBI has recovered most of the bitcoin ransom paid after the Colonial Pipeline hack.

WORLD'S FASTEST HDD
Seagate has unveiled its new dual actuator Mach 2 HDDs; the drives can reach a sequential data transfer rate of 524MB/s.

DOOM ON A LIGHT BULB
Some bright spark has managed to get *Doom* running on the Cortex-M33 processor inside a smart LED light bulb.

TRAGEDIES

ALIENWARE SUED
In 2019, Alienware said its new Area-51m was upgradable and a true desktop replacement. It isn't. Cue a class action lawsuit.

BYE, INTERNET EXPLORER
Microsoft is to kill IE next June—no more support, it's Edge all the way now.

APPLE'S ILLEGAL SHARE
After an iPhone repair, Apple had to pay huge compensation when private images from the phone were shared online.

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CHIA BOOM HITS DRIVE MARKET

But mining trashes consumer SSDs

WHEN THE NEW cryptocurrency chia was announced, it was expected to be a boon for hard drive manufacturers. Chia uses storage capacity rather than processing power to mine, employing a process called Proof of Space (PoS), rather than the traditional Proof of Work (PoW). The more capacity you can devote, the more you can mine. In China, a chia boom has caused drive shortages and pushed prices up by 50 percent or more. Already we have specialized chia motherboards, covered in SATA sockets and little else. By early May, chia was consuming 2.3 million terabytes of space in China, expanding by around 10 percent a day. The president of chia, Gene Hoffman, admitted that it had "kind of destroyed the short-term supply chain." Chia has indeed proved a welcome fillip for HDD sales. Seagate and Western Digital both report much higher sales. Both companies are now said to be "evaluating" the long-term effect of chia, and WD has increased production of its 18TB range.

Chia works on SSDs, too, and prices are expected to be pushed up by around 10 percent. However, mining chia solid-state-style isn't a good idea for consumer SSDs. PoS involves the creation of plot files, which use temporary storage; during the file creation, there are a lot of write operations. Chia's website warns not to use standard SSDs, but rather high-end, high-endurance SSDs designed for data centers. Chia is exactly the sort of thing you shouldn't run on SSDs, particularly QLC drives or TLC drives with SLC/MLC caches (quadruple, triple, single, and multiple level cache respectively). Basically, only run chia on an SSD you don't mind trashing. Luckily for us, the hard drives being sucked up for chia are all high-capacity ones; the supply of more modest drives for home rigs should be stable. **–CL**

WEBSITES DOWNED BY ONE USER'S CHANGE

Bug crashes Fastly's network of proxy servers

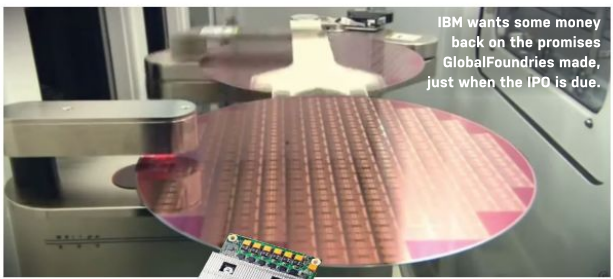
ON JUNE 8, a little before 9.47 a.m., one of Fastly's customers decided to change their settings. The change was valid, but it triggered a bug in the Fastly software, and things started to go wrong rapidly. About 85 percent of Fastly's CDN (content delivery network, a geographically distributed set of proxy servers) crashed. At 9.58 a.m., a status report from the company said it was "currently investigating potential impact to performance with our CDN services." By 10.44 a.m., it reported that "the issue has been identified and a fix is being implemented." The fix was in place at 11.36 a.m., and most services restored. By 12.41 p.m., all services had been recovered, although low cache hit rates remained a problem. The major outage lasted about an hour. This isn't a long time for one person to be without the Internet, but it is an age for many of the world's biggest online businesses to be offline. Victims included Reddit, Pinterest, Amazon, Etsy, Spotify, Twitch, PayPal, Quora, HBO Max, Stripe, and many major international news outlets.

Fastly is a cloud computing service provider, which you had probably never heard of until now, like many such companies behind the physical infrastructure of the Internet. CDNs sit between you and the online service you are using, providing a geographically closer, and faster, connection, all transparently. They are particularly useful for high-bandwidth streaming. Since there are only a few large CDN providers, the downside is that, as we've witnessed, if that extra layer fails, a lot of websites fall over together. Another big CDN provider, Cloudfire, suffered a similar but smaller outage last year. Having an active Internet connection has become necessary for much of modern life's activities; while at times it can appear a fixed thing, it is far from that. One person doing something perfectly innocent can still bring down large sections of it. **–CL**

IBM Sues GlobalFoundries

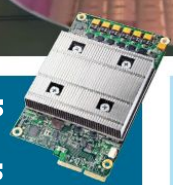
BACK IN 2014, GLOBALFOUNDRIES signed a 10-year $1.5 billion contract with IBM to build PowerPC chips. As part of the deal, the company got IBM's 14nm chip business, including designs and two fabrication plants, one of which was a 14nm 300mm wafer plant. This divested IBM of its fabrication capability, which had lost $700 million the year before. However, 14nm chips were beset by production difficulties, and the 10nm project hit technical hurdles and was canned. IBM would have to wait for 7nm, only that was canceled, too, as GlobalFoundries decided to exit the high-end chip market in 2018. IBM was displeased, and has broken out the lawyers, demanding $2.5 billion of compensation for having its chip roadmap trashed.

What went wrong? Well, a high-end chip business needs high-end investment, which you can only justify with big orders, which it didn't get. AMD's business went to TSMC, and IBM's orders wouldn't cover the bills. Meanwhile, IBM found a cheaper source for 7nm silicon at Samsung. However it is the timing of this case that has raised eyebrows. GlobalFoundries is preparing for an IPO, a potential $30 billion deal, so this sudden decision to sue looks opportunistic. GlobalFoundries' response says it is a "misguided and ill-conceived effort by IBM's law department to try to extract an outlandish payment ... that IBM knows it is not entitled to." Tough talk. **–CL**



IBM wants some money back on the promises GlobalFoundries made, just when the IPO is due.

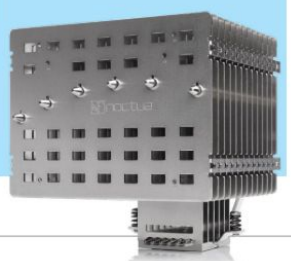
AI Chips Design AI Chips



Google is to use AI algorithms to help design the next generation of Tensor Processing Units, its custom AI accelerator chips. A year or so back, it published on the subject, and it appears to have got it working. Automating chip design isn't new. Back in the days of 10,000 transistors, it was a laborious hand-drawn job. These days, chips can have billions of transistors, so going old-school isn't an option. Enter chip design software, which helps map out the complicated web of transistors, tracks, and interconnects. The AI is particularly good at arranging the most efficient pattern, which is often rather haphazard-looking. If it works for the next TPU, the tools will be put to use on more complex designs. It'll be a while yet before it's ready for a CPU, but AI help is on the way. **–CL**

Heavyweight Passive Cooling

High-end silicon throws out a lot of heat, which limits passive cooling to the mid-range. But Noctua's NH-P1 was engineered to cool passively, and it is massive. Its Secufirm2+ Torx-based mounting system hangs its 3.3lb bulk from your board. Noctua says the NH-P1 isn't suitable for overclocking, and you may have to tweak the CPU boost modes to stop your processor overloading things, but it can cool an i9-11900K running at 3.6GHz with no fan. That's 125W of heat dissipation. The official price has not been finalized, but it is being listed at $100. **–CL**



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Jarred Walton

TECH TALK

A DLSS Competitor That Works on Any GPU

FOR THREE YEARS, we've been talking about Nvidia's DLSS tech—Deep Learning Super Sampling. The original DLSS 1.0 was a bit lacking, as it was limited in what it could do and required per-game training on Nvidia's supercomputer. DLSS 2.0 changed the underlying algorithm and made it easier to use, with better results. Now AMD has created a competitor: FSR.

The core concept of FSR (FidelityFX Super Resolution) is something we've seen many times. It will use a spatial upscaling algorithm so that games can render at a lower resolution, thus boosting frame rates. While there will undoubtedly be some loss in visual fidelity, the more pertinent question is whether gamers will notice or care.

We've seen upscaling algorithms since the first Blu-ray players arrived in 2006, attempting to improve the experience of watching lower-resolution DVDs (720x480) by scaling to 720p or 1080p. TVs and Blu-ray players can now upscale 1080p content to 4K or 8K, and the results range from OK to quite good. Hopefully, FSR lands on the higher end of that spectrum, but more importantly, it should provide a major boost to performance.

FSR will support four upscaling modes: ultra quality, quality, balanced, and performance. Game developers can also implement dynamic upscaling, where the algorithm isn't linked to a static resolution. Right now, AMD uses scaling factors of 1.3x, 1.5x, 1.7x, and 2.0x—in each dimension—so ultra quality, as an example, will scale 2594x1662 content up to 4K, or 1970x1108 content up to 1440p. The performance mode, meanwhile, renders a quarter as many pixels, the same factor that Nvidia's DLSS 2.0 uses in its performance mode.

There are plenty of differences between FSR and DLSS. DLSS 2.0 uses a temporal upscaling algorithm combined with a machine-learning trained network that attempts to upscale and remove jaggies. This network runs on the tensor cores in RTX cards, so it can only run on Nvidia's RTX hardware. Temporal upscaling uses the output of current and previous frames to try to optimize quality, and the end results have been impressive. DLSS 1.0 used spatial upscaling, which uses only the data from a single frame, with less-than-ideal results. FSR will hopefully manage to do spatial upscaling better than DLSS 1.0.

FSR promises large gains in performance via image upscaling, with four settings balancing quality against performance.

The bigger difference is AMD's open approach to FidelityFX, as the code and implementation details are part of the GPUOpen library of effects. AMD has already released contrast aware sharpening (CAS), variable rate shading (VRS), ambient occlusion, denoiser, and other effects under the FidelityFX umbrella, and there are more than 45 games that make use of one or more FidelityFX libraries. Perhaps the biggest benefit is that FidelityFX libraries are hardware agnostic, and can run on current and previous-gen AMD and Nvidia hardware, and even Intel GPUs.

The first games to support FSR will be existing titles, including *Godfall*, *Rift Breaker*, *Anno 1800*, and *Terminator Resistance*. Additional games including *Far Cry 6*, *Resident Evil Village*, and *Dota 2* will follow. Considering AMD provides the CPU and GPU in both the Xbox Series S/X and PlayStation 5, which will benefit greatly from improved upscaling algorithms, we're likely to see a lot more cross-platform games implement FSR in the future.

AMD's data shows a 40 percent improvement in performance using ultra quality, and around 2.5x improvement in performance mode. And that wasn't just on the latest GPUs; FSR could mean a new lease on life for older cards.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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PC GAMER

Christian Guyton

TRADE CHAT

Are Hard Drives Set to Return From the Dead?

YES, I KNOW THEY'RE NOT REALLY DEAD. HDDs offer an excellent source of affordable storage. But with SATA SSDs (and even M.2 drives) becoming cheaper and providing comically faster speeds, it's not hard to see why the humble 3.5-inch hard drive has fallen out of favor for many builders.

SSDs, particularly M.2 drives, open up new avenues when it comes to the physical act of building a PC, too. Many motherboards have slots for two (or more) M.2-2280 SSDs, taking up far less space than a pair of chunky HDDs. Ultra-compact builds benefit hugely from smaller drives that don't require SATA cables running around the case.

SSDs even offer higher capacities, although most M.2 SSDs you'll find online won't have a capacity higher than 8TB unless you're a big corporation with serious money to burn—but higher-capacity drives are sure to arrive in time. With insanely fast PCIe 5.0 drives on the distant horizon, it looked like the death knell for HDDs was close to sounding.

Not so, say researchers at the UK's University of Cambridge. New hardware experimentation has demonstrated that utilizing graphene—the impossibly thin artificial material—in place of conventional carbon for the protective overcoat of the spinning plate inside an HDD may offer a huge array of benefits, including greater capacity.

These carbon overcoats (referred to as COCs) protect the drive from corrosion and wear, and have been made progressively thinner since the 1990s, getting all the way down to 2.5nm. They are vital, with a thinner COC allowing for superior data density; in other words, more drive capacity.

Heat-assisted magnetic recording (HAMR) is a new method for data recording that involves heating the recording layer to higher temperatures, allowing for more precise reading and writing of data to tiny areas of the drive, which improves data density. HAMR technology had hit a snag, with carbon overcoats unable to sustain the increased temperatures without damage.

Graphene offered the solution. Dr. Anna Ott of the Cambridge Graphene Centre stated that new overcoats composed of a single graphene layer are "able to withstand HAMR conditions," opening the door to a new type of hard drive. Graphene produces double the friction reduction and superior resistance to corrosion compared to conventional COCs, as well as enabling better data density via HAMR technology.

COC-equipped consumer HDDs using HAMR were released earlier this year, with capacities maxing out at 20TB; new HAMR drives with graphene overcoats are hoped to hit 100TB within a decade, with Seagate recently stating that it expects to produce a 50TB HDD for consumer use by 2026.

> This IronWolf Pro HDD offers a mighty 18TB of storage, but we can go further....

But does anyone outside the serious corporate sphere need 100TB of storage? Seagate's proposed 50TB drives could be used to create NAS machines with 300TB or more, but I doubt that even a fraction of our readers would be interested in such absurdly huge amounts of storage.

Pricing is another concern. Graphene isn't cheap to produce, so new high-capacity HAMR HDDs are likely to have a higher asking price relative to their capacity. It's concerning, as Seagate's 18TB IronWolf Pro HDD already costs over $500, an eye-watering price considering that 6TB hard drives tend to be less than $150.

Unless you're handling huge amounts of data on the regular (like juggling 8K video files), these benefits might not mean much to you. But as drives continue to get bigger, so will files and software. In a decade or two, who knows; perhaps 20TB drives will be the norm, storing games that take up thousands of gigabytes of storage.

Christian is a game lover and hardware enthusiast, always seeking new tech. Follow him on Twitter: @GuyFromMaxPC.

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TALKING

BY IAN EVENDEN

Folding@home In Practice

Sergio Perez Conesa explains how Folding@home has helped his work in the field of biochemistry

A computational chemist undertaking a postdoctoral study at the KTH Royal Institute of Technology in Stockholm, Sweden, Sergio Perez Conesa uses Folding@home in the hope of uncovering a new drug or treatment for common illnesses associated with ion channels.

Sergio Perez Conesa spoke to *Maximum PC* about his use of Folding@home.

Maximum PC: Hi Sergio, thanks for talking to us. Can you give us an overview and insight into what it is you do, and what your work entails?

Sergio Perez Conesa: I have training in chemistry, but my work is multidisciplinary. I use a lot of physics, a lot of programming, and a lot of biochemistry, and ideas from biology, too. Our main tool is the computer, and the systems we want to understand are biological, but the way to do this is to understand the physics, and this we can get using a computer.

MPC: That's interesting. Obviously, the coronavirus pandemic is at the forefront of everyone's minds—did your research factor into that, and can you tell us about your work with the COVID virus?

SPC: Most of the work that has been done on the coronavirus has been done on the spike protein, which is the main protein that is outside on the surface of the virus. But since we work primarily with ion channels [proteins that form a semipermeable membrane that only allows ions of a certain size or charge to pass through them; they're present in the membranes of every single one of our cells, and are a prominent component of the nervous system], we tried to study the e-protein, which is a different protein in the membrane, in the outer part of the virus. There was very little structural information about that protein, so we didn't have very good models to start with, and we tried to use Folding@home to see if when simulating this protein, we would be able to fold it or rearrange it in some way, so that it would have a better structure. Unfortunately, this didn't happen.

MPC: So, coronavirus can even circumvent the Folding@home network to a degree. Where was the F@H system most useful, then?

SPC: Most of our more successful work with Folding@home has been in other projects, in ion channel studies in particular, which actually I'm going to get the data back on in a few weeks' time. I'm really excited about that, because I think those simulations are going to give us some interesting information.

We are studying one potassium ion channel that is a model for human and animal potassium ion channels, and these are really important, as they are related to how electricity moves in the body.

They allow positive charges—ions, potassium in particular—to go from outside the cell into a cell. And they have the property of being able to close and open in very conservative ways, so it's very much under control.

We study two things: how the environment, the cell membrane itself, affects how this conduction happens, and also the changes in the protein when it closes, so how it closes and why. If you understand better how these mechanisms work, you can better understand the pathologies related to the ion channels—such as epilepsy and heart arrhythmias—and then design better drugs to combat them.

MPC: So, what will you learn from this new data? What are you hoping for when it comes back? Is there something we

Folding@home can do the same amount of work as a supercomputer, such as Spain's MareNostrum 4.

should be looking out for in the media maybe?

SPC: The ideal result will be that my simulations are following the experimental data that we have available. That gives me confidence in my molecular models, but you want to go further than what is known from the experiments, so I'm going to train a machine-learning model to understand how the different compositions of the membrane, lipids, and fat that we have in the exterior of our cells is controlling the protein, and how that affects the conduction.

So, I want to first mimic the experiment, to see that my simulations are robust, and then I want to understand how the different parts of that protein are folding. They're like little machines in that way; they have small parts that have to expand and contact, and that is affected by their environment.

MPC: So, how does Folding@home factor into all of this?

SPC: What we do are simulations. Essentially, we take a model of the chemical system we want to study, we make a model in our computer of where all the atoms are, like where the water is, where the cell membrane is, the proteins, and so on. Then in the simulation, we see how those atoms move with time.

It's like a pilot who can simulate flying an airplane—it's not really flying, but since you have the right physics, you get the feeling you're flying. You get the information as if you were flying. And you can do things and understand things even if you're not flying a real airplane. So, even if it's not a perfect system, we can see how it evolves with time and understand how it works, because we have implemented the right physics.

These computations are very costly and very slow to run, so normally we use one of the supercomputers we have available. But the problem is that we're always wanting to see things that take longer, and are bigger systems, and for this we need more computational power. So we use Folding@home. It's a bit different, because instead of using one very powerful machine, we use many not-very-powerful machines, but we use so many that it compensates. It's a bit like if you wanted to map the coast of Europe—you could send one person walking along the whole coast by himself, or send 10,000 people, making a shorter trajectory each, then gather and sum up the results at the end. We do that—instead of doing one very long simulation, we do many, many short simulations, then gather the information and draw statistics from them. And that's the great advantage—we have access to a huge amount of computational power, thanks to the donors.

Our computational time is paid for by the government; we have funding from various different government agencies for us to do our research, and give back to the public in the form of publications or something like that. But it's the public that's donating the use of their computers for us to be able to do our research, which we then give back to the public, as our data is made publicly available, so other people can use it in their own research.

MPC: Folding@home gives you quite an advantage so far as computational processing power is concerned. If you weren't using Folding@home, which supercomputer would you be using?

SPC: We have several that we use: a small supercomputer in-house, and we have access to the PDC—I'm not sure what it stands for, it's probably in Swedish [Sweden's leading provider of high-performance computing services for academic research, its main system is Beskow, a Cray XC40 packing 53,632 Haswell Xeon cores, with a peak performance of nearly 2.5 petaflops]. But we can also apply for funding to use other supercomputers, such as one in Spain called MareNostrum [version 4 of which has 13.7 petaflops of Intel Skylake Xeons mixed with IBM Power9, Nvidia Volta, AMD Rome, Radeon Instinct, and ARM 64 chips across different "clusters," which are integrated depending on the needs of the job at hand].

MPC: That's some serious power. So, how did you begin working with Folding@home?

SPC: My supervisor knows many of the people who were originally running Folding@home, and with the huge increase in donors it recently received, thanks to the pandemic, they decided to open it up to more groups, and it's been a really good experience.

MPC: And what might we see from this work in 10 years?

SPC: My part is just a small one in a huge world of discoveries. My work and the work of many others can help us understand better how these ion channels function, and once we know this, we can know how to repair them when they have problems. The future of biochemistry is going to be dominated by computational methods; they will go hand-in-hand with experimental methods to understand disease. In 10 years' time, computers will really help to cure diseases much more than they are doing now.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

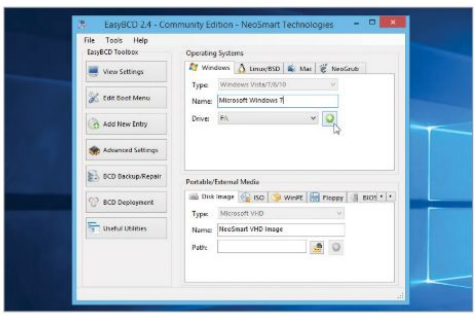
> Store Malfunction
> Boot Issues
> RGB Compatibility

No Store Downloads

My current problem is with the Microsoft Store. Having read somewhere (I think) that some future Windows 10 updates will be coming through the Store, and having discovered my Calculator app had stopped working some time ago, I thought I'd remove it and reinstall it from the Store. But while it comes up OK, whenever I click the "Get" button, nothing happens.

I've tried running WSreset.exe, which didn't fix things, and have tried resetting the Store under "Settings → Apps → Microsoft Store → Advanced Options," but still no change. I've also tried PowerShell commands—which I was able to verify had removed and reinstalled the Store—but that made no difference either. I've also tried signing out of my Microsoft Account and back in, but to no avail. The Store runs fine on my laptop, so I'm running out of things to try.

–Gerry Exstein



Remove unwanted dual-boot entries with EasyBCD.

THE DOCTOR RESPONDS: Ah, the Microsoft Store—bane of many a Windows user. OK, you've performed the basic repair steps, so next we need to widen the search for corrupt files: Right-click the "Start" button, open "Command Prompt (Admin)," and issue this command:

```
sfc /scannow
```

If errors are found, let it fix them and run the scan again. If it fails to resolve the problem, try DISM instead:

```
dism /online /cleanup-image /checkhealth
```

The check should complete in seconds on a fast machine. If problems are found, download the Media Creation Tool (www.microsoft.com/en-us/software-download/windows10/). Use this to create new Windows installation media, then make a note of the drive letter assigned to your media before issuing the following command, substituting the "X" with said drive letter:

```
dism /online /cleanup-image /restorehealth /source:WIM:X:\sources\install.wim:1
```

If this also fails, you're entering repair or reinstall territory. If the rest of your Windows installation is performing OK, ask yourself if you really need the Microsoft Store. There are plenty of non-Store alternatives to the Calculator app, such as Kalkules (www.kalkules.com), while Windows updates will continue to be delivered in the usual manner via its own Updates tool.

If you want to take things further, open the Windows Media Creation tool again, but choose "Upgrade this PC now" to perform the repair install, which is your final chance of fixing the problem without resorting to the nuclear option. And we say it again, is the Store really worth it? The Doc thinks not....

Boot Problems

I have a nine-year-old machine, which was state of the art when I built it in 2012. After having Win 10 installed alongside Win 7 in a dual-boot capacity, I've started to encounter two problems: First, it occasionally becomes very slow to respond to user input; and second, when I reboot to get rid of the problem, the BIOS refuses to boot into Windows 10 with the error message "A required device isn't connected or can't be accessed." The problem is temporarily fixed by booting into Windows 7, then running chkdsk on all the drives, but then it comes back again. I'd appreciate any help you can give me. **–Alan Darlington**

THE DOCTOR RESPONDS: Alan gave us a blow-by-blow account of his troubleshooting steps, as well as a detailed summary of his system. One extra piece of information

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↘ submit your questions to: doctor@maximumpc.com

he supplied was that his motherboard (Asus P8Z77-V Deluxe) came with a Lite-On 32GB mSATA SSD drive. It's this drive that we suspect may be at the root of Alan's woes. It is intended to act as a fast cache using Intel's Rapid Storage Technology (RST) utility, but is technically redundant now that Alan has installed SSD boot drives throughout his system.

The drive is problematic because it's the sole reason Alan still has a dual-boot machine, and the error he's getting on trying to reboot Windows is a classic symptom of problems with the boot configuration data (BCD), stored in the EFI system partition created on the drive where you installed your first OS—in Alan's case, Win 7.

When Alan asked his local computer store to update from Win 8 to Win 10 in January 2021, the system installer had wanted to replace his dual-boot configuration with a single Win 10 installation. He'd planned to disconnect all drives except the Win 10 drive, to ensure the installer created a new EFI system partition on the drive instead of simply updating the Win 7 EFI system partition. However, he decided the mSATA SSD drive was too difficult to remove, so "made do" by installing Windows 10 alongside Windows 7.

We suspect Alan's issues can be fixed by following the system installer's original plan. We're not sure why he shied away from removing the mSATA SSD drive—it's just screwed into the motherboard and is easy to remove. Once done, you can unplug all the other drives except for the one you plan to install Win 10 on, boot from your installation media, and make sure you delete all partitions on the drive during the install process—it then creates the required boot partitions alongside Win 10 and provides a single-boot setup that should work going forward.

If Alan wants to continue using Win 7, he needs to configure the Win 10 drive as the first boot device in the BIOS, switching between the two at startup by tapping F8 to bring up the BIOS boot menu. After booting into Win 7 for the first time, we recommend using a tool such as EasyBCD (https://neosmart.net/EasyBCD) to remove the redundant (and non-working) Win 10 option from its EFI system partition.

One final thing: This, of course, involves reinstalling Win 10 from scratch, so make sure you've backed everything up before you begin. Treat this as an opportunity to wipe clean and get things properly in order going forward.

Not all lighting systems are compatible with each other.

Lighting Setup Issues

Aloha Doc, I've completed my first custom build in a long time, with a lot of new components. I have a Corsair iCUE 5000x RGB case, with the included Corsair PWM and LNC. I added a Corsair Commander Pro. I built that up with an Asus ROG Crosshair Hero VIII, Phanteks Glacier One 240 MPH AIO, and added a Corsair QL 120 RGB rear exhaust fan, and two Corsair QL RGB 140mm top fans.

The problem is that I'm unable to get the RGB working on any of the fans. I've tried several iterations of connections to the mobo and LNC and Commander Pro, all to no avail. The fans all spin just fine, and I have all the necessary connector cables, but I can't seem to get the RGB part working. I need some guidance please. **–Dave Cobb**

THE DOCTOR RESPONDS: The world of lighting is exciting and confusing. Before embarking on setting up your first lighting rig, the Doc recommends reading this beginner's guide from Reddit: www.reddit.com/r/buildapc/comments/ku117m/a_beginners_guide_to_rgb_in_2021/. The crucial point is that many solutions are proprietary and won't work with each other. That means you can't connect the Phanteks Glacier One to the LNC to control the lights. Thankfully, all is not lost, as you can connect it directly to your motherboard, so use the supplied three-pin D-RGB motherboard adapter to connect the cooler to one of the Addressable Gen2 LED connectors (see the manual for placement details). It should light up when you power on, confirming it's connected correctly.

You'd think removing this from the equation would mean the QL fans would work with your setup, but no. QL fans are a different type from the three SP RGB Elite fans included with the Corsair 5000x case, so can't be connected to the same controller. You need to connect the QLs to their own Corsair RGB fan LED hub ($9.99—see www.corsair.com/us/en/Categories/Products/Custom-Cooling/Accessories/CORSAIR-RGB-Fan-LED-Hub/p/CO-8950020 for details), which plugs into one of the spare LED channels on the Commander Pro.

Again, when connected correctly, you should find the first fan in each sequence lights up when you boot. Now install both Asus Aura from the "Support" section of your mobo's page on the Asus website and the latest version of iCUE, then link them using Corsair's guide (https://help.corsair.com/hc/en-us/articles/360041797351) to get all the fans working in unison.

Explorer Resets

I've got a bizarre behavior going on with a new PC I built: Windows crashes but doesn't blue screen; instead, what I'm guessing is Explorer.exe blinks out, resets, and then Windows tries to move on. I don't get a dump file or a crash code. Instead, all my browser tabs crash and any game I'm playing force quits. I see no evidence of overheating, and tested each RAM stick. The GPU was from a previous stable build. I've tested my m.2 drive with Samsung's software and it's marked healthy. Is there any chance this new form of Windows reset is generating a dump that has more clues? **–Tzvi Sherman**

THE DOCTOR RESPONDS: The problem you're seeing is more likely to be software-related. Is there any pattern to the bad behavior? For example, does it crash when you right-click in File Explorer? If you can trace the start of the problem to a specific incident—such as app installation (or update), you have something to work from.

Also look at Event Viewer: type "event" into the Search box to open it. A summary appears—any Explorer reset is likely to appear under "Error" or "Warning," so expand each and browse through the list looking for any likely events linked to your problem. Double-click one for more details, including a date and timestamp of when it occurred, which may help identify the issue. Use the information to hopefully learn more and find a fix—failing that, get back in touch with the Event Log info, and the Doc will investigate further.

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THE ULTIMATE

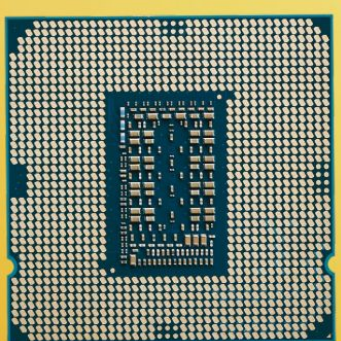
BUILDER'S GUIDE

Take a peek at how we go about building PCs, as there's always time to learn something new

By Christian Guyton and Sam Lewis

WHETHER YOU'RE a PC-building veteran who has more machines under their belt than Origin PC, an intermediate builder who's comfortable but has scope for more knowledge, or if you have all the gear but no idea, this guide contains all the tips and tricks to make building a PC an enjoyable experience. If you are reading this, chances are you have a keen interest in PCs, and even if this article isn't immediately helpful, it will be at some point in the future.

Custom PCs are our true love; they aren't necessarily cheaper, and certainly aren't easier than a pre-built plug-and-play machine, but the advantages are significant. The sky is your limit (well, that and your wallet), but you get full control over what goes inside and how you want your PC to perform. Remember: There may be problems along the way, even if you are an old hand, so here are 38 tips to help make your builds go smoothly.



RGB PRO // SL
VENGEANCE
noctua
NT-H1
ZOTAC

(01) Plan Ahead

Before you start getting your sledgehammer out, you need to think about what you want to use your PC for predominantly. Also, for legal reasons, please don't use a sledgehammer or any large destructive tool for your build—many thanks. Back to what you want; you could be after a PC that is completely productivity-focused for video editing or designing, or maybe you want gaming monster that can run at ludicrous FPS and shatter all other PCs within a 50-mile radius. Even if you just want one for work and the odd bit of Netflix, it's important to nail down what demands you want to make of your PC, as this determines what parts you need. The difference could even affect which OS you use (that's right, we're not just shills for Windows 10). So, make sure you research what makes your ideal PC perform to its best. Also consider where you will put your PC and how you want it to look; will it be on display? Tucked under a desk? Sitting in your living room? Remember: Planning your build always comes first.

(02) Research

The Internet is filled with useful information on PC components, hardware specs, reviews, and tutorials to help in your build. Video guides, in particular, give a great insight into how a part functions, looks, and fits inside a build. When finding out what components to get, research similar builds and you'll eventually get an eye for what makes that system good for its intended purpose. You will likely find a common denominator and from there you can look at how to complement that component with other parts. It is also worth looking on the manufacturer' websites and through their PDFs for installation advice, and a component compatibility check on pcpartpicker.com wouldn't go amiss, either. It's a great place to start virtually piecing together your PC parts. All of this is essential before diving deep into your new rig.

(03) Bare Essentials

When building a new PC, the place to start is the case; we always recommend this. Take a good look around, making sure everything is as it should be, and strip it all down. Remove any side panels, dust shields, and windows. To help with airflow and cable management, it's best to remove any hard drive cages and additional mounting brackets if you're not using them. This maximizes negative space, producing more room for you to keep things neat and tidy. Unfortunately, we all know that tempered glass panels are a fingerprint magnet, so be careful that you don't smudge all over it when removing this panel. New cases usually come with a protective film over any glass parts, so wait until you're done building to take this off.

You should start any build with a bare, stripped-down case.

(04) Pick a Fan

For both rockstars and PCs, fans are essential (sorry). The bottom line is that a PC would inevitably overheat and cook if it weren't for the intake and exhaust fans that regulate the internal temperature. There are two categories that fans fall into: bulky static pressure models and thin, many-bladed airflow fans. The former is designed for high-pressure environments, such as moving air through a thick heatsink. The latter moves air faster through the case, but with reduced force. Mounting multiple airflow fans provides good airflow to your PC, shockingly enough. Static-pressure fans, however, are vital for radiators if you choose to run with an all-in-one cooler. Some fans utilize magnetic bearings to "levitate" the fan inside its casing, which prolongs the lifespan and reduces noise, but naturally comes with a larger price tag. Most modern PC case fans use ball-bearing mounts, which should still last for around 60,000 hours at 50 C.

(05) Fan Management

Luckily, most cases come with one or more fans pre-installed. These are typically stock manufacturer fans, or sometimes fans from a partnered brand. They do the job when it comes to keeping your PC cool, but generally won't stand up to fans from dedicated manufacturers. If you're after a silent build or cooling overkill for many sessions of demanding rendering tasks, there are plenty of better options out there than the stock fans. If you plan on upgrading the stock fans, make sure you do this before installing anything else (or simply remove your motherboard assembly as one unit first if you're upgrading an

These are the same fans with different blades. The thicker blades are optimized for high pressure, while the thinner blades are for improved airflow.

When you buy a Silent Loop 240mm all-in-one, a pair of Silent Wings fans is included as part of the overall package.

existing system). Things can start to get tight and awkward inside the case, so it's best to get any clutter out of the way. Consider keeping the stock fans as well as new fans if you've got the room; the more the merrier. If you're replacing your rear fan with something flashier, you can always push the stock fan to the front of the case to pump up the airflow.

(06) Speed Control

A topic often debated in the industry, there are pros and cons to both slow and fast fan speeds. A higher RPM (revolutions per minute) produces greater airflow, but is obviously louder. Smaller fans demand a higher RPM in order to work effectively, so don't go for a fan for your case that is smaller than 120mm unless the circumstances demand it, or you're liable to end up with some significant fan noise. An integrated fan control unit can be found in some PC cases. This is a pretty neat feature, enabling you to alter the speeds on the fly with software or an external remote. However, please remember to crank them up when 4K gaming, otherwise you'll end up having a pretty toasty gaming session.

(07) Faces Suck

Fan orientation sounds basic enough, but it can be easy to make a small mistake that ends up harming your PC's thermal performance. The majority of fans feature small arrows on the plastic frame indicating the spin direction, and also the direction in which they push air. Another way to check is to look at which side of the fan the power cable protrudes from. When mounting multiple fans on a single section, such as two fans on either side of a heatsink tower, or stacked in the front of your case, make sure they are pumping air in the same direction for maximum efficiency. Since the front face of the fan almost always provides air intake, a nice little trick to remember which way around it should go is to recall the phrase "faces suck."

(08) Cable Threading

Good cable management is a lifesaver, especially in smaller and cheaper cases. Install your PSU early on, before the motherboard, and you will be able to pull the cables through first. Space is more precious than gold when it comes to PC building, and if your case has integrated cable management, that's great—this is usually comprised of Velcro straps on the backplate, which help keep the mess out of view. If your case doesn't have this luxury, fear not, because the mighty cable tie will help you out. Don't forget that you can feed smaller cables directly underneath the motherboard before installing it. Cheaper PSUs are likely to come with a bundle of cables you won't be using. Neatly gather these up with a cable tie and store them away, beneath the PSU

(09) MADE FOR YOU

Right now, trying to scrounge together the parts for a complete new system build can be a nightmare. Some components are still readily available; cases and power supplies aren't selling out like hot cakes, at least. But if you've tried to buy a GPU recently, you'll be well aware that stock shortages and scalpers are proving ruinous to anyone trying to build a home PC. With new cryptocurrencies such as chia starting to threaten SSD stocks, too, the prospect of purchasing a fully equipped pre-built PC starts to look attractive.

Pre-built systems do have some advantages over doing it yourself; guaranteed tidy internals and manufacturer-assured assembly mean that issues such as overheating and component incompatibility are seldom a problem. It can also be a relief to have that catch-all manufacturer guarantee to fall back on if your system fails, rather than having to figure out which component is busted, and determine if you still have a valid warranty.

A pre-built system lacks a few things against custom builds; they're not bespoke, and some contain obstacles to future upgrades, purely by nature of their construction. If you're looking for the ideal purpose-built PC, you're better off taking the leap and assembling it yourself. Manufacturers' ability to bulk-purchase components means that pre-built systems can contain high-end parts at a relatively low premium, though, and there's a degree of assurance that the chosen parts will function optimally together. Many also come with unique cases that can't be obtained elsewhere. These are often compact and aesthetically pleasing, as they can be designed to fit perfectly around the system inside.

Pre-built systems have come a long way; current offerings from companies such as Chillblast and CyberPowerPC are powerful and effective, although they result in a heftier price point. Higher-end pre-builds are generally a better option, so if you're assembling a PC on a tight budget, DIY is often the way to go. Some companies selling pre-built PCs offer the option to customize your new machine entirely, cherry-picking exactly the parts you want for an additional fee.

Pre-built systems can come in very elegant cases that are often out of reach.

© MSI

shroud if your case has one. Out of sight, out of mind (soft of).

(10) Processor Cooling

Another crucial part of keeping your system's temperatures down is cooling its brain, the CPU. There are three options for this: a traditional air cooler, full liquid cooling, or an all-in-one (AIO) unit that uses both fans and liquid coolant. The first is typically what comes in the box with your processor. These stock coolers are decent enough, and generally not too hard to install, but don't provide high-level cooling. Complete liquid-cooling loops are tricky to install and cost significantly more, but their performance is unparalleled. The best option is generally to go for an AIO cooler. They provide top-notch cooling with a large degree of flexibility, and little to no maintenance. If you're overclocking your CPU, a good AIO cooler is highly recommended.

(11) Air Pressure

In any build, you probably want your case to have balanced air pressure. This means that the case draws in air at roughly the same rate that it pumps it out, keeping airflow steady and temperatures lower. Alternately, positive air pressure means your PC draws in more air than it expels—this can prevent air entering through unfiltered sections of the case, potentially reducing dust build-up. The difference in temperature is relatively minimal, but if you're serious about cooling, balanced air pressure is generally better—test both out using stress-testing benchmarking tools such as Prime95 if you're curious about the results. There is also a third option—negative air pressure, but you want to avoid this, as it builds up more dust inside your case.

(12) CPU Installation

The beating heart of the build, the CPU is the core of what makes your PC tick. The two main central processing unit manufacturers are AMD and Intel. AMD CPUs are a little easier to install; simply lift the retention arm, slot the CPU into place by lining up the gold triangle on one corner with the matching corner on the socket,

Always make sure the arrows are matching and take your time—CPU pins are super-delicate.

Accompanied by a rewarding click, sticks of RAM are very easy to add to your build.

then lower the arm back into place. All done. Intel CPUs are a tiny bit more complex, with pins mounted on the motherboard rather than the processor itself, and a metal bracket that sits over the CPU socket. Lift the retention arm, then slide the bracket out from under the fixed Torx screw, and raise it to reveal the socket. Line up the CPU and place it in the socket, then lower the bracket and retention arm back into place. Intel motherboards come with a plastic cover over the CPU socket; this should snap off automatically once the CPU is properly locked in.

(13) Install Memory

The easiest thing to install on a PC build is probably the RAM. The DIMM slots have either one or two clasps on their short edges; ensure these are open first. The base of the memory stick will have a little notch in it—line it up with the notch in the memory slot, then push it down. It should give a nice satisfying click when it is inserted, with the clasps popping shut automatically. The only thing with RAM installation is that you need to make sure that it goes in the correct slots. They are usually not numbered in order on the board, although they may be color-coded to indicate which slots use which channels. For dual or quad-channel support to work properly, the RAM needs to be installed in the correct slots. If you're unsure, check the motherboard's manual; it'll let you know exactly which slots to use.

M.2 SSDs are installed directly on to the mobo; undo the little screw, and slot the drive into position.

Remove the two PCIe blanking plates from your case before dropping a graphics card into the slot.

(14) Drive Installation

When using a conventional HDD or a 2.5-inch SSD for storage, install it in the case on the relevant mount, then simply run a SATA cable from the drive to the motherboard. Alternately, if you're using a faster and flashier M.2 SSD, things can be a little bit cleaner, by which we mean no cables. Make sure the mounting peg is in the right position for the

length of your SSD, then remove the tiny Phillips screw and fit the drive into the slot. You may have to insert the connector end of the SSD first at a 30-degree angle to fit it in securely, then push the drive down gently to screw it in. Many motherboards come equipped with a heatsink for the M.2 drive, which needs to be removed before installation, then secured on top of the drive afterward. Don't forget to remove the protective seal on the heatsink's thermal pad; we've all been there and done that, and it smells like burning, so please avoid the momentary panic.

(15) GPU Installation

As it is likely the biggest piece of hardware that will sit on your motherboard, please be careful when installing your graphics card. Along with the sheer size of the majority of GPUs comes the ever-increasing price, so that's just one more reason to treat this step with extra care. Dropping one of these on to a motherboard risks damaging both parts. First remove the expansion slot covers from the rear of your case, then ensure that the clip on the PCIe slot is released. Similar to the RAM slots, it automatically snaps shut when the component is properly inserted. Position the GPU with its I/O in line with the rear of the case, then gently push it down until you hear that satisfying click once again. Secure it to the case with screws straight away. This principle also applies to other PCIe components such as soundcards. For best performance from your graphics card, insert it in the uppermost PCIe slot.

(16) Power On

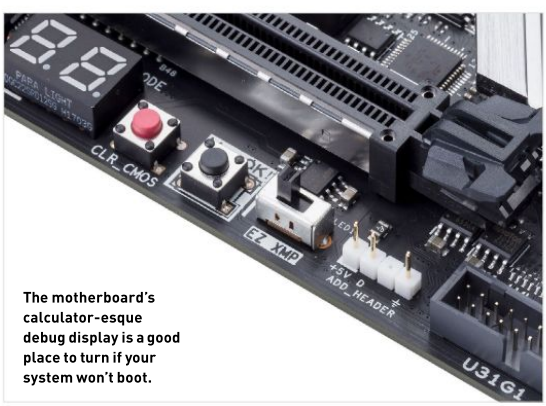
The first thing to look for if your build won't boot is the motherboard's debug display. Not all mobos have one—it's usually a calculator-esque seven-segment display, although some high-end boards have a small screen for displaying error codes. Take to Google or consult the motherboard manual, and you should be able to find the specific issue. If you're not sure, or your board doesn't have a display, these next few tips should guide you through.

(17) Hurdles

Memory is frequently the issue when it comes to a build that doesn't boot. Of course, we wouldn't wish this on anyone, but it's good to be prepared just in case. If you can access the BIOS, you should be able to see whether the memory is being detected properly by the system. If not, or if the BIOS isn't registering all of the DIMMs properly, try removing your RAM. Check that the sticks are installed in the correct slots; if they are, but it's still not running, give the additional slots a try. As a last resort, try reinserting the GPU and CPU.

(18) Energy Checks

Is everything plugged in? We mean no offense by this question, but we have all been a victim of this



The motherboard's calculator-esque debug display is a good place to turn if your system won't boot.

© CORSAIR

(19) RGB OR NOT RGB?

RGB lighting is a topic of much debate at the *Maximum PC* office (and on every single computer hardware forum in existence, in fact). It's tempting to use it in your build, though. RGB coolers and fans are becoming more prevalent, so it's easy to be drawn in. And RGB has spread to other components, too, with even power supplies now able to sport a glowing rainbow fan for a few dollars more. Those little additions often add up, though.

A pair of premium maglev case fans from Corsair will run to around 30 dollars, while the company's RGB counterparts cost easily that much for a single fan. Stick-on LED strips aren't too expensive, but can require expansion kits and RGB controllers, which drive up the price if you want to properly synchronize your system's lighting. And, of course, you need a case that shows off your multicolored lights; that means tempered glass or even pre-installed RGB lighting, which could result in a less than sensible total cost. At the very least, control software for most branded RGB kits is free to download.

A good rule of thumb when it comes to RGB is to simply ask if you could get the same performance for a cheaper price without the lighting. If you're going to spend an extra 50 dollars on a case just because of its glass front, consider how much time you're going to spend looking at your PC against how much time you're going to spend looking at the screen. Putting that money toward a superior monitor is always going to serve you better, especially if you're operating on a budget. But if you've got the money to burn or you come across an RGB component that performs just as well as its same-priced competitors, go right ahead and turn on the rainbow.

Filling (or draining) your custom loop can be nerve-wracking.

(20) STAY FROSTY

A full custom liquid cooling loop can be a struggle to get right, but it does come with one major advantage: lower running temperatures, potentially generating more thermal headroom for CPU and GPU overclocking. Fans can be run slower, resulting in less noise compared to pump whine, but if you're running a powerhouse PC that is going to produce a lot of heat, liquid cooling is the way to go. Creating your own loop is a costly process, though, demanding a budget of at least $500 to be done right in most ATX cases.

Planning out the build is absolutely necessary if you're going to be installing coolant tubes in your case. We recommend taking a side-on photograph of your chassis and using your picture editing software of choice to plan out the positioning of your components and tubes, using arrows to ascertain which direction you want the coolant to flow. The larger your case, the easier it becomes; reservoirs and radiators can take up a lot of space, although you're probably going to end up spending more money. Smaller cases may demand the drilling of holes through metal frames to feed through tubing; for this, you'll want a wide-head drill bit designed for use on metals. Angled fittings can remove the need for bending your tubes; while flexible tubing is an option, hard tubing is easier to secure in place and tends to look better in a finished build. If you're really serious, you can use a heat gun to soften and reshape hard tubing to fit your case perfectly, although this can damage the plastic if done incorrectly.

The pump needs to be gravity-fed by a reservoir. When it comes to radiators, a good rule of thumb is to have at least 120mm of radiator space allocated per component being cooled. For example, if you want to connect your CPU and your GPU to the same coolant loop, you're going to want a minimum radiator size of 240mm.

problem. The GPU isn't connected to the PSU, the front I/O wires aren't powered, the boot drive isn't plugged in properly, and so on. If everything looks as though it's in the right place and the system is visibly powering up, but you're still staring at a blank screen, try using a different display cable. HDMI and DisplayPort cables are notorious for failing when you need them the most, particularly if you are using cheaper ones.

(21) OS Install

Maybe it's not hardware-related, and instead it's software that is causing all this stress at what should be such a happy time—the first boot of your custom-built PC. When transferring an older drive to a new build, there is potential for this issue to rear its ugly head. It's generally caused by existing driver or program conflicts, resulting in a failure to boot. OS files are susceptible to corruption, too. If this is the case, resets and updates aren't likely to resolve the issue. The only option that might fix the problem is to reinstall Windows completely to your boot drive. Unless you're specifically trying to migrate a system to a new case, we recommend installing a fresh copy of your operating system of choice with each new build.

(22) Hardware Testing

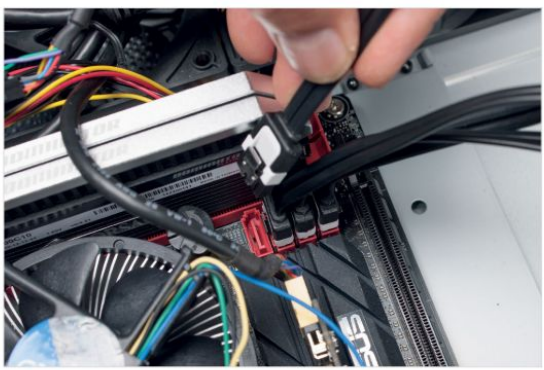
Components can die. We get it, it's awful and distressing, but it does happen, and it's best to be prepared. If you want to do some final checks before calling the RMA line, you'll probably need a second (functioning) PC. You can test RAM sticks by plugging each one in separately and attempting to boot. With other parts, you can test them on another motherboard in a working system, or replace them with another part you are certain is functioning correctly. Do this with each component in turn (we advise starting with your CPU and GPU), until you identify the part that is causing you grief. While repairing minor damage to individual components can be an option for enthusiasts—such as straightening bent CPU pins—you're best off cashing in the manufacturer's warranty if one of your parts dies.

(23) BIOS Update

Updating the BIOS via the Internet is supported on most modern motherboards, but if it isn't on yours (or the online update fails to work, which isn't uncommon), you can usually get the update manually from the manufacturer's site. Download it on to an empty USB flash drive—not one filled with your pet pictures—then plug it into the mobo's rear I/O. Within the BIOS's advanced mode, find the update option. Select "Update from storage," locate the file on the memory stick, and you are all set.

(24) Install the OS

If you need a fresh install of Windows 10 for your new build, head straight over to www.microsoft.com/en-us/software-download/windows10. Download the Media Creation Tool, and select


Just a single loose cable can lead to your PC not booting.

Tools of the Trade If you're gonna build PCs, you need the right equipment; these are the key tools you'll want to have close at hand

(25) SCREW BOWL You can splurge on a magnetic bowl for your screws if you want, but any little bowl will do the trick. Even a simple teacup will work. The important thing is to keep all of your screws in the same place when you're working on a rig; they can be easy to lose, and that only leads to frustration.

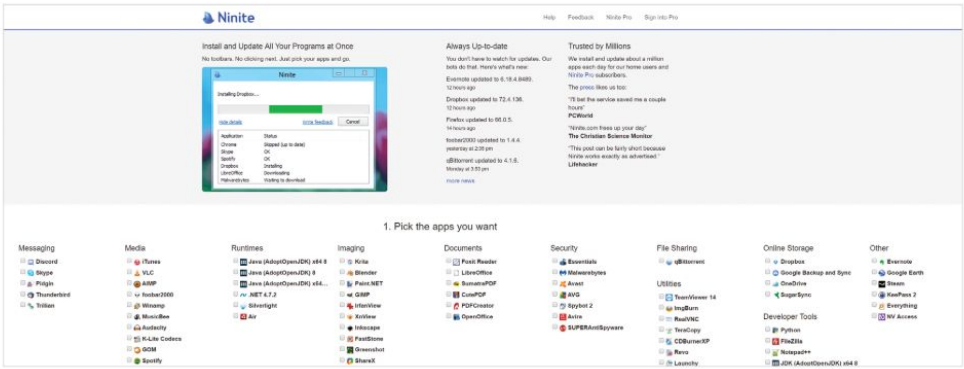
(26) ISOPROPYL ALCOHOL If you're planning on switching out your processor or cooler, you're going to need this stuff. It's inexpensive, and nothing is more effective when it comes to cleaning off dried thermal paste or dirty smudges on metal. As an added bonus, it's one of the few substances that isn't going to kill your components if it spills. As per the warnings on the bottle, handle with care.

(27) THERMAL PASTE Most coolers come with a tube of the manufacturer's own paste, but this can be poor. Our go-to is Noctua's NT-H1; it's not particularly expensive, and Noctua coolers come with some—one tube is good for multiple applications. Remember: You only need a pea-sized dot on normal Intel and AMD CPUs.

(28) CABLE TIES These are vital for any PC-builder. They're dirt cheap and come in a variety of sizes for different uses—in our case, primarily for organizing cables. Most chassis have slots on the frame for you to strap down cables, keeping things tidy, and they can also be used for securing bundles of unused power cables from non-modular PSUs to keep your case neat.

(29) SCREWDRIVERS A Phillips-head screwdriver will serve you well in most situations, but a proper driver set is worth the money. Allen screws, tiny M.2 drive screws, and bizarre proprietary screws will all prove frustrating unless you've got the right tool to coerce them loose. Mag-tip screwdrivers are recommended, as they're a godsend when dealing with small screws inside a case.

(30) SPUDGER This little gadget will set you back barely a dollar or two on Amazon, and can come in very handy. Used by the tech-repair pros at iFixit for prying apart stubborn components, its thin plastic edge can also be used to gently realign bent pins on AMD processors.



"Create Installation Media on to a USB drive." Plug said drive into your new build, and then boot it up. If it doesn't work, head into the BIOS and adjust the boot order, setting the flash drive containing the installation media as the priority. From there, just follow the on-screen prompts to set up the operating system and activate your copy of Windows 10.

(31) Update Drivers

Unless you've been lucky enough to snap up a brand-new GPU on release—and, let's be honest, that ain't happening right now—you're going to want to head over to either the Nvidia or AMD website, and download the most recent driver update. This will ensure that your graphics are running up to speed. If you are using an older motherboard, you may need to update the chipset first. On the manufacturer's website, find your product, then grab the latest drivers, and follow the installation instructions. You might also want some additional drivers here; look for audio and LAN drivers in particular, and remember that the chipset needs to be installed first.

(32) Light Show

When it comes to installing RGB lighting, ensure that the strips themselves are not directly visible from the windowed side of your case; nobody wants to see that. Light should always be shining on to your components, not out of the case, providing a softer illumination that showcases your build. Find spaces and corners to conceal the lights, either inside the lip of the case's edges or beneath the black border of a tempered glass panel. Using two strips installed at right angles in a corner creates a more even spread of light across your motherboard, but remember that if you're using fully addressable RGB lighting, it's important to make sure that it is all synchronized up properly.

(33) Install Software

So, you have a brand-new, custom-built PC, and it may look really fancy, but what's the point if you aren't going to play that scary maze game on it straight away? On a more serious note, you do need to get some software installed in order to get the most out of your new toy. A good one-stop-shop for this is Ninite.com, which enables you to choose from a selection of key programs to quickly and easily download to your C: drive. Ninite also keeps these up to date automatically. If you're a gamer, you'll likely have to do legwork; while Steam is on Ninite's list, other platforms, such as Origin and the Epic launcher, aren't. Similarly, if you use higher-end image or video manipulation software, you'll have to venture out and find this yourself.

Ninite is a great one-stop site after your rig is built.

***Maximum PC's* 2019 Dream Machine, filled to the brim with RGB lighting.**

(34) RAM Settings

Another part you should take a look at is your RAM settings. Double-check that the memory is running at the correct frequency and CAS timings, then enable XMP settings if you're overclocking. You can attempt to manually pump this up, too, but be careful—DRAM voltage increases of more than 10 percent can prove lethal to your sticks.

(35) Color Coding

It's generally best to stick to white lighting unless your setup has a specific theme, and then it's always nice to tie your PC build in with the rest of your room's design. White lighting gives your components a good amount of definition, without drowning out any RGB effects your mobo is putting out. Bright single-color LED strips are likely to just highlight the predominant colors on your components, flooding the body's appearance with blue or red. If your strip allows for brightness

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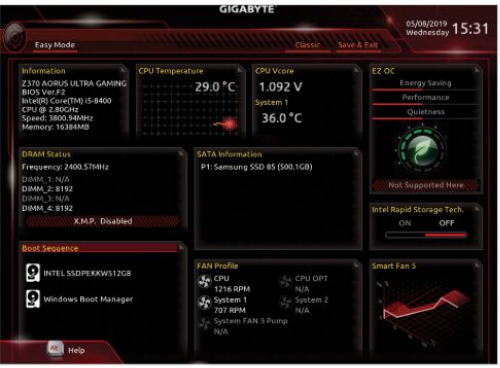


Knowing your BIOS is crucial if you want to get the very best from your PC.

control, opting for a slightly more conservative light level is a good call. Addressable RGB is great, provided you ensure that you can synchronize to retain an appealing pattern across your entire build.

(36) Use the Warranty

If you can't work out what's wrong with your build—or if you can, but you can't fix it—there's one more port of call: the warranty. Most brands come with a decent warranty nowadays, and some components even come with a lifetime guarantee—very generous. Customer service is generally good—if they can't diagnose the issue, you're likely to get a fresh replacement part, provided you haven't done something horribly wrong to the offending component. Don't be afraid to raise a ticket even for minor issues; when it comes down to it, customer services are the experts.

(37) Brand Loyalty

Although extended warranties are one of the key reasons we recommend sticking to recognizable brand-name components, you're also more likely to get superior build quality, durability, and longevity. If you're not sure when purchasing, check out the manufacturer's website, and read some reviews on reseller sites. If you can't find many (or any) reviews, tread carefully; don't be lured in by a low price and an obscure manufacturer name. If the product is only available on Amazon, not tech-oriented outlets such as Newegg, be wary.

© GIGABYTE

(38) STOP THE CLOCKS

Overclocking is something to take seriously. If you want to push your hardware to the limit in order to secure additional performance, we strongly advise reading some more in-depth guides on how to do so properly, lest you end up bricking your build. Extreme overclocking beats up the components being used (whether that's a processor, GPU, or memory), which can result in thermal damage to your system if you're not cautious.

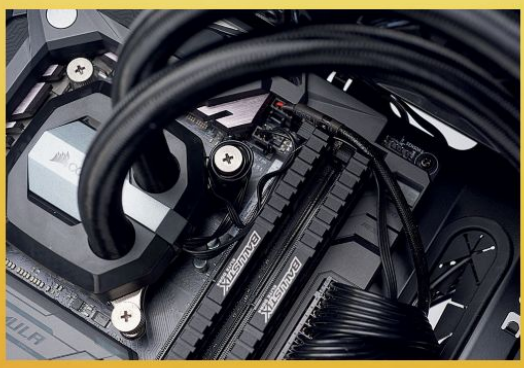
At a fundamental level, CPU overclocking is achieved by raising the frequency at which the processor runs, and raising the voltage supplied to the components to compensate for the additional speed. GPU and memory overclocking works similarly, but we won't get too into that here, as CPU overclocks will likely make the most difference to your PC's performance.

Due to the silicon lottery, CPUs of the same model may have slightly different limits when it comes to the overclocks you can achieve. This is done by accessing the motherboard BIOS and manually raising the frequency at which the CPU will attempt to run. Depending on the capability of the processor, this could be anything from 0.1GHz to 1GHz above the base operating frequency. If you're running a high-end chip, you should be able to squeeze at least 0.5GHz out of it.

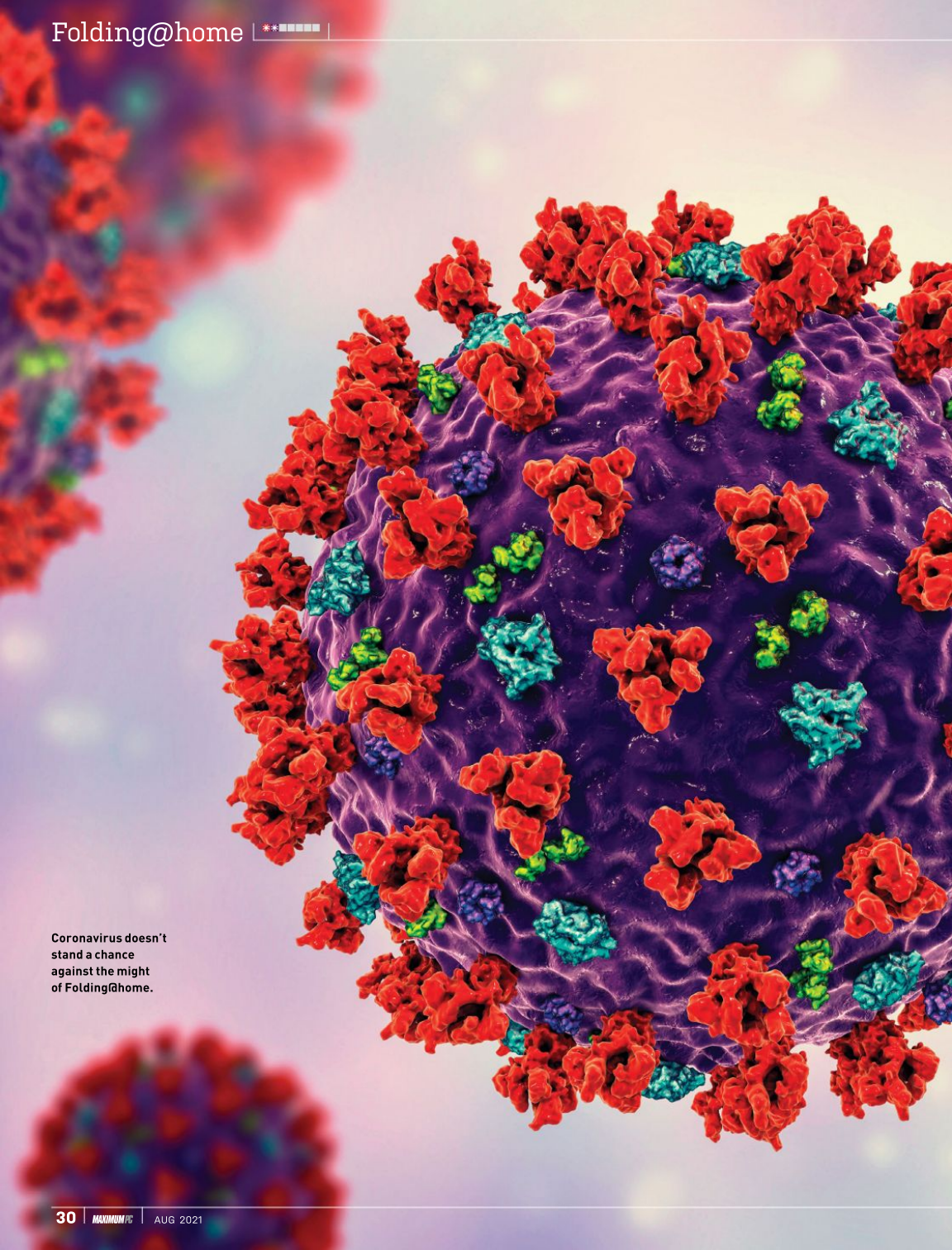
Keep raising the operating frequency in small increments in the BIOS, booting and restarting each time. At a certain point, the CPU will refuse to boot. To get past this, head back into the BIOS and raise the voltage, usually by 0.05V at a time. Of course, doing this also raises the temperature, so it's vital to have decent CPU cooling if you're going to overclock—a stock air cooler simply isn't going to cut it, so be sure to splash out on an upgrade.

If you've got a high-end AIO cooler, though, you can use a stress-testing program, such as Prime95, to push your CPU to full resource usage and assess the maximum running temperatures you're likely to hit. Test it between changing the BIOS settings to ensure that you're not in danger of frying your chip.

After a while, you'll hit a stage where it's impossible to get the frequency any higher, regardless of the applied voltage. At this point, dial it back by 0.1GHz to secure a more stable overclock, and run some more benchmarks to ensure it isn't about to die on you. If your PC crashes or you hit temperatures that exceed safe operating levels, lower the frequency by another 0.1GHz, and try, try again.

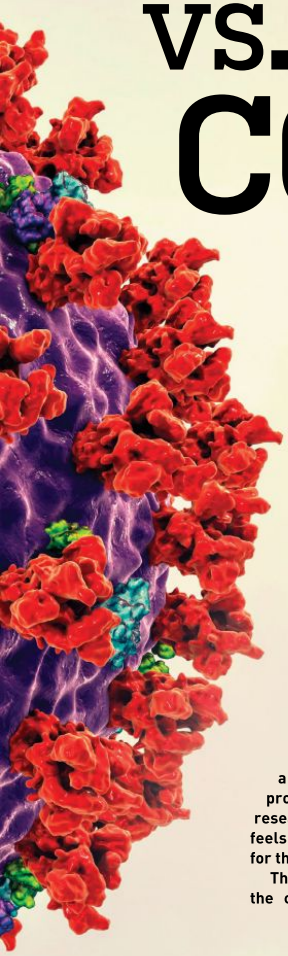


Powerful AIO coolers are a good bet if you plan to overclock your CPU.



Coronavirus doesn't stand a chance against the might of Folding@home.

CORONAVIRUS VS. THE GIANT COMPUTER



How Folding@home took time off from curing cancer to tackle a pandemic

WHEN THE *Maximum PC Illustrated Bumper Book of World History* is written, the years 2020 and 2021 will get their own chapter. Not because of politics but because of the global pandemic and shortage of microchips.

Folding@home will probably need a lot of coverage, too—a citizen science project contributing to biochemical research projects that is free to add to and feels extremely cool while you do it (except for the heat it pumps out of your PC case).

There's not much we can do about the chip shortage, but the pandemic and Folding@home collided beautifully. It led to Folding@home becoming the fastest supercomputer on the planet, hitting one exaflop (a 1 followed by 18 zeros) on March 25, 2020, then peaking at 2.4 exaflops the next month. That's as powerful as the top 500 (known) supercomputers combined. And that much power folds a lot of proteins.

But why would we want to fold proteins in the first place? Look up any image of one online, and it seems pretty well folded already—all spirals and ribbons, like your little sister's hair on her birthday. The record was there for the taking, however, so here's how Folding did it.

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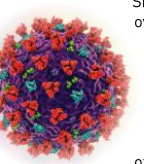
BY IAN EVENDEN

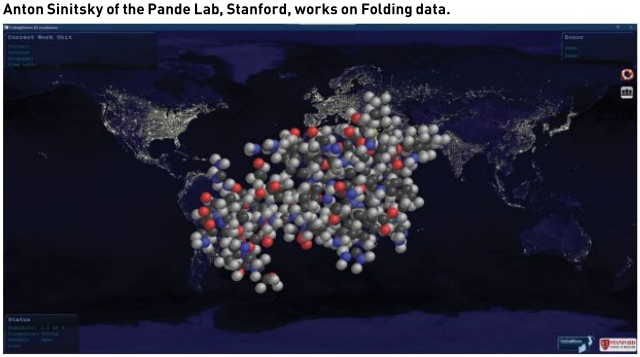
FOLDING@HOME is used to breaking records. "Back in 2010, 2012, we had a client on the PlayStation 3," says Anton Thynell, head of collaboration and communication at Folding. "That's where we took our first Guinness world record for the world's strongest distributed computing network, with I think 800,000 PS3s and a couple of hundred thousand PCs. Folding@home has a very strong community, and it's well known in tech. I think what resonated most, though, is that you can donate your computing power to research. We're not asking for funding, we're asking for computing power, and that power is directly connected with the simulations researchers are running."



Since its launch back in 2000, over 200 scientific papers have been produced as a direct result of Folding@home processing, including one in June this year, published in *Nature Chemistry*, that announced the discovery of "cryptic pockets" on the surface of the virus that offer targeting options for new antiviral drugs, as well as epitopes—protein fragments that are capable of stimulating an immune response. This is a clear-cut breakthrough, and we dread to think how long it would have taken had Folding not been able to scale up so effectively. The data and models are being made freely publicly available.

Protein folding is a complicated thing to simulate—the exascale computer Folding created for its COVID paper managed to simulate just 0.1 second in the life of the virus's proteome (all the proteins that are, or can be, expressed by a genome)—yet the benefits from doing so are huge. Protein misfolding is a causal factor in a number of diseases, including some cancers, allergies, Alzheimer's disease, cystic fibrosis, sickle-cell anemia, Creutzfeldt-Jakob disease, and type 2 diabetes. Then there's the way viruses, including HIV, influenza, and coronavirus, enter our cells—they have a protein on their surface that folds to be like a key, and this attaches to a lock on the surface of the cell, opening it up for infection if the key is just the right shape.

Anton Sinitsky of the Pande Lab, Stanford, works on Folding data.



Folding's visualizer, which comes with the client, gives an idea of both the complexity of the molecule being simulated, and the location of Folding participants.

You may have heard of the "spike" protein on the surface of the coronavirus virion, and this is the key that opens our human cells to its contagion. Once open, the virus inserts its own genetic material—DNA and RNA—and tricks the cell into following these plans instead of its own, producing more virions. Other diseases, such as Alzheimer's, see fragments of misfolded proteins, known as prions, build up in the brain as plaques, which interrupt normal brain function. A curious property of prions is that they can transmit their misfolded shape to other, normal proteins, causing them to misfold and clump together.

This is unfortunate, because proteins are essential for the normal operation

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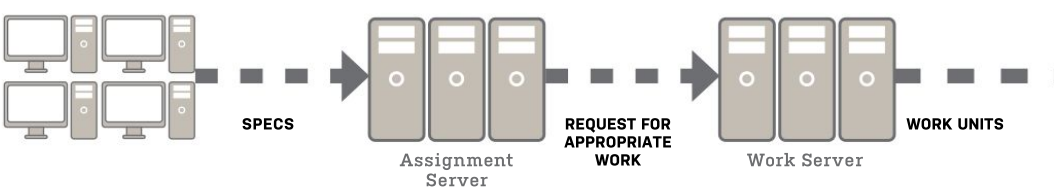
FOLDING@HOME'S JOURNEY



of our bodies. These complex molecules have a 3D structure, and it's this that allows them to do their work, in the same way the proteins on the virus allow it to open your cells like a key. If they fail to fold properly, they often become inactive, but sometimes they acquire modified or toxic functionality. (Interestingly, we frequently unfold proteins into their original linear state; a process known as denaturation. It involves heat, and we call it cooking.)

The spike protein remains a tempting target, even though it has defenses, such as glycan molecules that act as shields. It also opens and closes, protecting the sites that bind with human cells—and therefore could be targeted by drugs—to evade the immune system. Folding has simulated the opening of the spike, showing how it binds to human ACE2 enzymes, which are located in cell membranes and play a role in reducing blood pressure, using them as an entry point into our cells.

What Is a Protein?

"A lot of attention gets paid to one other large molecule that's essential for life, and that's DNA," says Katie Hart, assistant professor of chemistry at Williams College, Massachusetts. "DNA is like the software, but the proteins, the enzymes, they do the chemistry. They are the structural bits that comprise your hair and various parts of yourself. Proteins are linear chains, so you can think of them as beads on a string, where each bead is an amino acid. They're linked in a particular order depending on what the protein does, so before it can do anything, the chain has to fold into a complex 3D structure."

The order the beads appear on the string is crucial for how the protein will fold. "The rules for what that structure looks like are actually all encoded within that sequence of amino acids," Hart continues. "You will always end up with sort of the same structure, simply because you have different flavors of amino acids. They have different chemical and physical properties, so some of them might be positively charged, others negatively charged, and the positive ones want to be nearer negative ones, and away from other positive ones. Some of them may be greasy or oil-like, while some are water-like and those want to be also kind of clustered together, so the oil-like amino acids want to cluster together and the water-like ones want to cluster on the outside. So, using a few simple rules you can predict what the final three-dimensional structure might look like."

The cleverest part of it all is that proteins do this spontaneously. Hart calls it "beautiful," and she's right. Chain together the right sequence of amino acids, then put them in water, and they will fold up and become a molecule of your hair, or fingernails, or muscle. Every. Single. Time. But this raises an obvious question: If we know how a protein will fold by looking at its parts, why do we bother simulating them in the world's largest supercomputer?

Well, it turns out that if you have many, many amino acids in the chain, it's actually quite difficult to predict precisely what they're going to do. "Once you have the problem of hundreds or thousands of these amino acids, and all of the shapes they could form, and all the ones that they're not going to form, it gets a little bit difficult," says Hart, who we suspect is understating the matter slightly. "On the one hand, it's an interesting question from the perspective of understanding the

ALPHAFOLD PREDICTS THE FUTURE

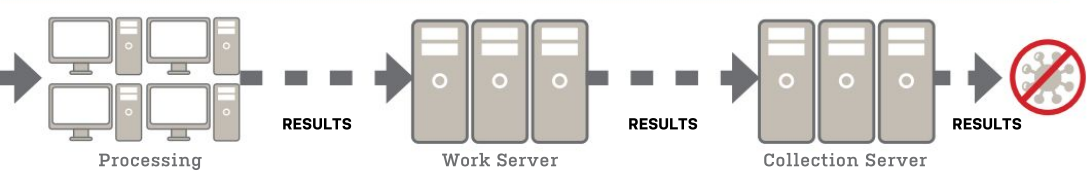
Folding@home isn't the only group that's interested in folding proteins. Google, via its faintly terrifying offshoot DeepMind (which has an AI that can play *Starcraft* much better than you can), has also been having a go, but its AlphaFold software takes a rather different approach.

Essentially, what AlphaFold has been able to do is sidestep the whole inconvenient simulation process, and go straight from looking at the flat chain of amino acids to its final 3D shape by predicting how it will fold, then honing that prediction to a remarkable degree of accuracy.

"It's a game changer," Andrei Lupas, an evolutionary biologist at the Max Planck Institute for Developmental Biology in Tübingen, Germany, told *Nature*. "This will change medicine. It will change research. It will change bioengineering. It will change everything."

AlphaFold has been at this a while. Every two years, a challenge called CASP (Critical Assessment of Structure Prediction) is held, in which scientists vie to most accurately predict the final 3D form from a linear chain. AlphaFold won in 2018, and was way ahead in the 2020 contest, with two thirds of its predictions equivalent to the results achieved by X-ray data.

While not yet perfect—it can take days to come up with a prediction—DeepMind's deep learning approach looks significant and could lead to whole new disciplines, such as protein design and the study of how they have evolved. "This is going to empower a new generation of molecular biologists to ask more advanced questions," Lupas continued. "It's going to require more thinking and less pipetting."



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physics and the chemistry of the process. From a biological or human health perspective, all of your proteins have to fold to function, so if they're not folding properly, then that can be a problem."

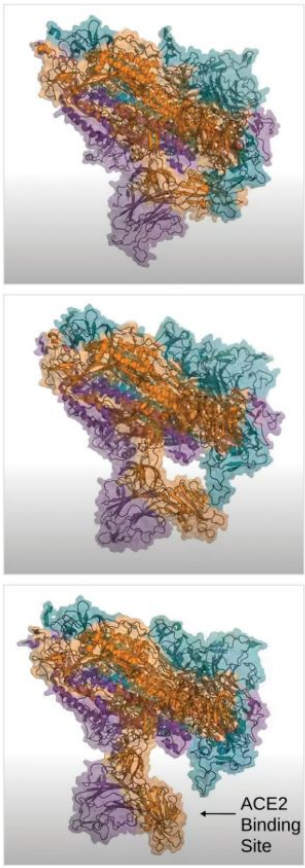
X-ray vs. Computer

Before computer simulations, protein structure was determined using X-ray crystallography, in which X-rays were fired at a crystallized protein (to stop it moving about) and the diffraction patterns produced translated into the coordinates of its atoms, which could be built into a 3D structure using the ball-and-stick models that are as much a part of the ideal science lab as a skeleton in a white coat.

As we've seen, there are a lot of diseases that are caused, at least in part, by problems with proteins. We can add to that list aging disorders, where the same sort of plaques that in the brain might cause Alzheimer's build up in other organs of the body. "Being able to prevent misfolding or promote proper folding using drugs or therapies is one of the main kinds of biomedical relevance of understanding protein folding," says Hart. "Protein folding is not just about achieving the final, folded structure. Proteins are highly dynamic, meaning they move around and wiggle a lot. So, we need to understand not just how a particular string of amino acids folds into one structure, but also how it moves and rearranges in solution to form a whole family of similar-looking structures. Then we can better design drugs that target these structures—just as Folding@home has been doing most recently to discover drugs that target proteins in COVID-19."

Ah, yes, that pesky pandemic. Millions of new donors—computing time donors—flocked to Folding when it announced it could apply its technology to finding a cure, or at least a treatment, for the disease ravaging the globe. At the beginning of 2020, there were around 30,000 devices donating their spare computing time to the project. At the time, one of the big areas of research was in myosin motors, molecules that move along the cytoplasm of animal cells, turning ATP, the universal chemical energy currency of the body, into mechanical movement along microfilaments within the cytoskeleton, the protein structure that exists inside every one of our cells.

Make tiny changes to these myosin motors, and you change their function. This was interesting work that opened up new ways to fight Ebola, and showed how an existing antiviral drug, Baloxavir, could be repurposed to fight



These frames from a Folding@home video demonstrate the spike protein on the SARS-Cov-2 virus opening, and show where it binds to the human ACE2 site.

thrombocytopenia syndrome virus, which is spread by ticks in the US, and has a mortality rate of up to 30 percent.

"All the labs that are connected with Folding have their own focus," says Thynell. "We're talking about biomedical research, disease research, it depends on the different labs. If you take Washington University in Saint Louis, for example, they focused on the Ebola virus and through Folding@home they've uncovered some potential druggable sites. Ebola has been called undruggable, but through their simulations we could discover previously hidden sites [for drugs to interact]." And that was going extremely well, until the scale of the COVID-19 pandemic revealed itself and Folding pivoted all its attention on to the new threat. Within two weeks, 400,000 new devices had signed up, pouring the resources of 4.8 million CPU cores and 280,000 GPUs into discovering the secrets of SARS-Cov-2. An internal joke at the project was that this effort generated more simulation data than had been created in the entire history of science to that point. It looks like it might be true.

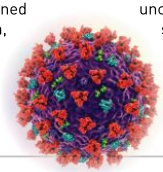
Another problem with COVID is that, for something just 200nm across, it's quite sneaky. Take the Nsp16 protein—this helps the virus avoid the human immune system because it's very similar to CMTr1, a normal human protein. Design a drug to target Nsp16, and you have to be careful you don't take CMTr1 down, too. Folding has discovered (see *Biophysical Journal*, March 2021) that there are druggable sites on Nsp16 that don't appear on CMTr1, paving the way for an antiviral drug.

Worldwide Effort

Look at the map of where Folding's donors are in the world, and the US and Europe glow brightly, but so does Japan, parts of South America, the west coast of Australia, and both islands of New Zealand. There are outcrops of donors in Russia, India, South Africa, Hawaii, most of Southeast Asia, and what we think are the islands of Reunion and Mauritius, though geography was never our strong point. The Caribbean is ringed by dots representing donors, and a single dot glows way north in the Canadian Arctic. There's a very real sense of the world coming together to fight back, almost like at the end of a harrowing sci-fi movie.

Speaking of movies, a lot of fantasy and sci-fi references are used to describe the project. Not only is the spike protein on the surface of the coronavirus referred to as the "demogorgon" (to be fair, the spike protein opening really does look like the creature from *Stranger Things*' mouth), but lead researcher Greg Bowman, writing on the Folding blog, describes the effort to target the coronavirus as being like "the citizens' fleet in the movie *Star Wars: The Rise of Skywalker*. Everyone came together to face a common foe."

Thynell uses a *Star Wars* reference, too. "We look at Folding@home as being a bit like the *Millennium Falcon,"* he says. And before we can speculate about what he's smuggling, continues: "The *Millennium Falcon* isn't the perfect ship, but it's doing its job very well, and it's the fastest ship in the galaxy as far as we know, right? That's Folding@home for



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you. We were one part-time engineer and tons of great community."

So, should we visualize Folding as running on a few old Macs in the corner of a lab, or as a sleek stack of server blades in an air-conditioned data center? The truth is somewhere in between.

"The Folding@home Consortium has at least one work server," says Thynell. "The client first connects to the assignment server, from where we can measure how strong your computer is in terms of CPU and GPU. Then you connect to the work server to get a project that's fitting for your rig. The researchers upload their simulations to the work server, which are then distributed into the grid. When you've finished a project, you return it to the work server, and when the entire project is completed, it's moved over to a collection server, which is more like cold storage; its speed is less important. The work server requires SSD drives, while the collection server uses mechanical hard drives."

These servers are dedicated to Folding, but remain part of Washington University in St. Louis, and could be used for other things if not needed. Servers have been donated from the data industry, too, as has lots of computing power. Look at the list of top donors and you'll see the Nvidia Saturn V, a GPU-powered supercomputer built for AI applications that seems to spend its spare time folding proteins.

All these GPUs in one place puts a question into our heads: Could someone infiltrate Folding and get it to mine bitcoin? We're not the first, it seems. "People have been asking that," Thynell says. "And it's not possible at all. Folding@home is based on two cores, and both of them are open-source research tools. What you download is these two cores, and then a wrapper and a front end, so you couldn't run any crypto-mining even if you wanted to with that client. You'd need to create a new client with different logic."

Dr. Greg Bowman (pictured center, brown shirt, along with the rest of the Folding team) is Folding@home's chief researcher.

Folding@home's web interface is where you can see what it's processing right now, and even choose the disease you're interested in fighting.

Moonshot Drugs

Back to the more serious business: All that computing power is beginning to bear fruit against COVID. "Folding@home has been part of a larger effort called the Covid Moonshot, and they are at the end of animal testing right now with an oral inhibitor for SARS-Cov-2. The working thesis is to create a pill you'd take when you have symptoms—trials are successful so far, but it's hard to say how it will materialize. This would help countries that won't be running a vaccination program in the near term, as there's still a lot of vaccines left to be distributed."

This is obviously huge news. The Moonshot project is especially interesting because, as well as being open source and patent-free, it represents the coming-together of diverse groups such as the Diamond Light Source (the UK's national synchrotron science facility, like CERN only smaller), the Chodera Lab at the Zuckerman Research Center in Manhattan, the Weizmann Institute of Science in Israel, and private companies giving their resources for the good of humanity from China, India, Europe, and the US. A rather honest Q&A on the site admits they don't know how they're going to profit from the research, although the cynic in us suspects they'll find a way. Funding is currently handled through GoFundMe, with all money raised spent on the synthesis and testing of compounds, while any that remains unspent will be donated to fund not-for-profit research into the prevention of pandemics.

The Moonshot works by testing molecules against simulations of the COVID virus to see what effect they have. Those molecules aren't random; they're designed by chemists as a "best guess" at what might interact based on research like the discovery of the Nsp16 protein's vulnerability, and Folding's new *Nature* paper is likely to stimulate more. Over 14,000 such molecules were submitted, and in six months, over 1,000 were tested. One—the inhibitor—kills the virus in human cells without damaging those cells, but there are three other promising compounds on their way to testing.

"It's been really nice to be able to contribute to that, even though Folding@

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Katie Hart is assistant professor of chemistry at Williams University.

home concentrates on simulations," says Thynell. "Our understanding of SARS-Cov-2 will be very good now, thanks to all we learned from the simulations, and our basic knowledge will be fruitful for future pandemics. If this virus comes back in another form, we have more information than we had previously." This is true, too, for the work involving the Nsp16 protein we referred to earlier. The protein is the same in the coronaviruses that cause COVID-19, SARS, and MERS, so a drug that targets one could potentially be used against all of them, and future variants.

ARM Unleashed

As a result of the sheer amount of data the project is generating (Amazon Web Services provides infinite buckets for it to keep its datasets in), the team behind it is expanding, and a non-profit organization is being set up to handle the grants and funding. "We really want to provide a great experience, but we don't have a triple-A budget for it, so we're doing the best with what we have. We're onboarding more engineers, and we're going to improve the client," says Thynell, before revealing the software will soon be available on more devices, including low-powered ARM machines. "So, you could have your Raspberry Pi running Folding@home, if you want."

That's going to mean further specialization of the projects the server sends out, retaining the heaviest work for those with gaming GPUs to spare, reserving those that would respond to multiple CPU threads for multicore monsters, and having a supply of lightweight, shorter projects for ARM devices. "We have projects where it doesn't make sense to run one very long calculation," says Thynell. "But instead a lot of very short calculations, and it's better to run those on an ARM device than on a GPU. It's the same back end for ARM devices, we just flag them differently in the system to make sure they get the right projects and not something designed for an RTX card." Exploring Folding@home's statistics page can be fascinating, seeing how the work breaks down by OS, which projects are popular (cancer was the most-gunned-for condition when we last looked, with COVID in second place), and being able to see the faces of the researchers, and read what they hope to do.

In this sense, and much like the viruses it simulates, Folding@home is constantly evolving. "We've been around for 20 years, and we're still going to be here in 20 years' time," says Thynell, before getting Trekky again. "We're the *Star Trek Enterprise* in the field of biomedical research. We are on the front line, and what Folding@home is doing today will be industry standard in 10 years' time, so we are moving the field forward, too. We're really making a difference in mapping out and learning more about the blueprint of the human body, and also getting people engaged. One thing we're focusing on in the future is educational content, and trying to improve our user experience. Understanding what's happening, and getting feedback from the client about what it's doing, could be better.

"The new generation is used to *Fortnite*, so it has to be as simple as *Fortnite* [to get Folding running]. We have an open-source developer community, and we're doing more and more in collaboration with our communities. We're on Discord and GitHub if anyone wants to get in touch."

Folding@home represents something wonderful—the world coming together to fight a threat, putting aside things like borders and business interests and our built-in distrust of one another. If it can create an exascale supercomputer to fight one virus, think what could be achieved if we attacked other problems in this collective, community-minded way. In 20 years' time, when our PCs will be so much more powerful, we may think of COVID and Ebola in the same way we think of smallpox today, a relic, consigned to that big book of world history by technology.

GET STARTED WITH FOLDING

If your PC is connected to the Internet, there's nothing stopping you from beginning to fold immediately. Point your browser at https://foldingathome.org/#downloads and choose your operating system. From there, install the client, and set up an account. Perhaps join a team, which pools the research carried out by multiple donors and turns it into a kind of competition between teams as to who can process the most work units. There's a *Maximum PC* team, naturally: number 11108.

The minimum specs are very low, in the Pentium 4 and Windows XP range, but the more cores you can give it, the happier it will be, and only a limited number of projects are available for 32-bit systems. Once connected, you'll find the client lurking in your system tray. There are two control panels: Web Control, which runs in the browser, and gives you a basic overview of what Folding is doing with your system; and Advanced, which is its own app, and gives you more detail and more control. You can pause the process, set how much of your system's resources you want it to use, and whether you want it to use both your CPU and GPU (multiple GPU owners can add a second GPU slot, and potentially process three work units in parallel). You can also set it to only work when your PC is idle, leaving all the power for you when you want to work.

We had to turn the "Power" setting down to "Medium" on our AMD Threadripper/Nvidia RTX machine, simply because the heat it was generating from running full-tilt was making it uncomfortable to work in our office. Watch out also for clashes between Folding and your antivirus software—if this happens, exclude the "Folding" folder from your antivirus scanning list.

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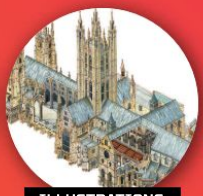
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THE SCREENS OF TOMORROW

With chip shortages, the crypto-mining craze, and painful pricing for all kinds of components, we're hardly operating in normal times when it comes to PC tech. Without mentioning the p-word, let's just say the world has more to worry about right now than overpriced GPUs.

Excuse the pun, but screen tech hasn't been immune to the madness. Yet progress continues. In fact, after years of headline-grabbing advances in gaming panels, the next 12 months might offer the best chance to upgrade a tired productivity-oriented screen.

The introduction of the first mainstream OLED monitors this year is certainly a milestone. Likewise, wider adoption of mini-LED backlighting is a game changer. The mere availability of affordable monitor models that combine a quality 32-inch IPS or VA panel with 4K resolution and 120Hz-plus refresh could actually be what marks 2021 as a really significant real-world inflection point.

If the value of high refresh outside of a gaming context is debatable, the wider adoption of USB Type-C and the associated Thunderbolt 4 as the display interface of choice is surely an unambiguous win. So, if you've been holding out for an upgrade for that aging 1440p or 4K 60Hz SDR panel, it could be the time to finally pull the trigger.

Not that the next year or so will satisfy all your monitor-related hopes and dreams. The stubborn refusal of the market to embrace resolutions beyond 4K doesn't look likely to change anytime soon, for example. We'll all have to wait a few more years for that elusive high-DPI experience, at least when it comes to large-format displays where 4K doesn't deliver the goods in pixel density terms. But in most other regards, the incoming options look sweet. –JEREMY LAIRD

Move over gamers, it's time for plain old productivity panels to get in on the upgrades

For gamers upgrading PC monitors, the last few years have been going gangbusters. Refresh rates keep climbing. Features such as low input lag modes and adaptive sync are cheaper and more widely available than ever. Panels with all kinds of crazy curves and aspect ratios are now almost the norm. Forty-nine inches of uber-curved 5K gaming monitor running at 240Hz? Not a problem. You can even get a massive 4K OLED 120Hz gaming screen for a not completely insane amount of money, though that will strictly speaking be a TV and not a monitor.

The market for more productivity-oriented panels? Not so much. Four or five years ago, monitors offering resolutions around 4K in various shapes and sizes running at 60Hz refresh got cheap. Since then, bar one or two ultrawide options, there hasn't been a lot to upgrade to. At least, not for vaguely sensible money.

Yes, HDR support has arguably made some inroads, but true 1,000-nit-plus HDR capability with per-pixel lighting in a PC monitor remains a long way off.

However, the next 12 months or so are beginning to shape up very nicely for anyone pondering an upgraded productivity panel for their PC. One really significant technological development is the introduction of mini-LED technology. You can check the boxout opposite for a deeper dive into the comparison between mini-LED and microLED. The short version is that mini-LED is a backlight technology for LCD panels, rather than an actual panel type. However, it still promises a big step forward in image quality and especially HDR performance.

That's because it allows for thousands of individually controlled local dimming zones. LCD monitors with conventional LED backlights and local dimming

Apple's Pro Display XDR is a 6K, 32-inch mini-LED beauty. But it's painfully pricey.

capability contain at most 300 to 400 zones. The ability to split the backlight into 400 individual zones may sound impressive, but on a 4K screen it means each zone is powering over 20,000 pixels.

Long story short, that relatively crude level of local dimming results in obvious image issues, including blooming around bright objects. White text on a black background is particularly problematic. Upgrade hundreds of zones to thousands of zones, and much more precise control of contrast across the panel becomes possible. As a consequence, this new wave of mini-LED panels will arguably enable the first LCD monitors with true HDR capability. The catch? As ever, it's cost. At least in the short term.

The very first mini-LED models are megabucks. Dell's 32-inch 4K UP3221Q has 2,000 zones and costs $4,000. The Asus ProArt Display PA32UCG-K packs 1,152 zones and commands a few hundred dollars more, while its 27-inch sibling, the PA27UCX-K, is yours for around $3,000, and makes do with just 576 zones. However, several mini-LED models are due later this year with more affordable pricing. Philips's 27-inch 279P2MRX, for instance, ups the ante to 2,304 zones and an eye-popping peak brightness of 1,400 nits. Philips hasn't quoted a price just yet, but we're hopeful the 279P2MRX will be one of a few more affordable mini-LED models.

Next up is OLED technology. It's been an awfully long time coming to the PC. But it's finally happening, and not just in laptops. OLED panels in premium laptops from big brands such as Alienware and Razer have been available for several years with reasonable success. Attempts to introduce OLED technology

In recent years, the monitor market has been all about gaming panels like the crazy Samsung G9.

© SAMSUNG, APPLE CORP, TCL

to the desktop, however, have been much more problematic.

As long ago as January 2016, Dell announced the UP3017QA, a 30-inch 4K OLED monitor that seemed to signal a new era for desktop displays. It was delayed to April 2017 due to image quality issues, only to be discontinued two months later. With a peak brightness of only 300 nits and concerns over color drift and burn-in, plus a $3,500 price tag, the UP3017QA never looked like a great prospect.

The Asus ProArt PQ22UC, another 4K OLED monitor, was announced in 2019. At a mere 22 inches and $3,900, the PQ22UC is a niche offering. It can still be bought today, so it has at least lasted longer than the ill-fated Dell. For 2021, however, LG is introducing a pair of new monitors that represent the first real attempt at introducing OLED tech to the desktop.

The LG 32BP95E and LG 27BP95E are 32-inch and 27-inch 4K OLED monitors priced at $4,000 and $3,000 respectively. Intriguingly, given LG is the world's biggest maker of OLED panels for TVs, both are based on panels made not by LG but bought in from a panel producer known as JOLED. It's a little detail that hints at the cost and complexity of tooling up application-specific OLED panels. Even the world's leading manufacturer of large OLED panels buys them in for some of its own screens.

Of course, neither of those two new LG monitors are terribly affordable. Which is why a new OLED panel from AU Optronics (AUO) in particular is good news. AUO doesn't make complete monitors, rather it sells LCD and OLED panels to display makers. The panel in question is a 32-inch item with 4K resolution and 144Hz refresh. That's a very sweet-sounding

Mini-LED sounds confusingly similar to microLED, but it's essentially just the latest backlight technology.

Samsung's microLED technology is absolute megabucks.

MINI-LED VS. MICROLED

WHAT'S IN A NAME?

There are lies. There are damned lies. And there's flat panel marketing. It's common for LCD monitors and HDTVs to be sold as "LED" displays when, in fact, the LED bit is just a backlight. Let's not even start on the nonsense monitor makers get up to when it comes to specifications such as pixel response.

The way screens are sold is only getting more confusing with the emergence of two new LED technologies: mini-LED and microLED. They sound awfully similar, but they have vanishingly little in common. Mini-LED is just another backlight tech, albeit the most advanced yet, whereas microLED is a panel type in its own right.

In really simple terms, microLED is the future for display tech, the ultimate flat panel. Mini-LED is just the latest and greatest version of LCD technology. If that makes mini-LED sound like it's playing second fiddle, in technological terms it is.

Even the best mini-LED panels come with nearly all the shortcomings of any LCD screen. Mini-LED does nothing to help with the limited viewing angles or relatively slow pixel response of an LCD panel. Indeed, it's remarkable just how good LCD panels have become given how unsuitable the technology is for full color motion images. But however good the backlight technology, LCD will remain a flawed transmissive technology.

What mini-LED does achieve is improved contrast control and supercharged HDR performance. Essentially, mini-LED involves an array of thousands of tiny LED lights, typically grouped into individually controllable zones. A panel might have tens of thousands of LEDs, but fewer zones, perhaps a few thousand. The idea is to achieve more finely grained control over backlighting and reduce problems such as blooming around bright objects or white text on a black background, which are common issues on existing LCD monitors.

In comparison, microLED has numerous advantages. It's pretty much the same as OLED technology, but without the burn-in issues and with much higher brightness. If that sounds like the perfect display, well, it probably is. It's the ultimate in per-pixel lighting, for sure. No brightness limitations, fantastic viewing angles, near infinite contrast, near instant response.... What's not to like?

There's a catch. Until recently, microLED was limited to tech demos and a few expensive displays aimed at commercial installations. That is now beginning to change. At CES this year, Samsung showed off its "consumer" microLED TVs. They are more conventional screens than any previous microLED display, with full feature sets including smart TV and audio capabilities, plus HDMI inputs, and everything you need to plug in and watch stuff. But the 110-inch variant is over $100,000.

Granted, cheaper variants are due any day, shrunk down to a paltry 88 inches. But you're still looking at $50,000's worth of TV. Which means we are at least five years away from affordable microLED TVs. Sadly, microLED PC monitors will be even further out.

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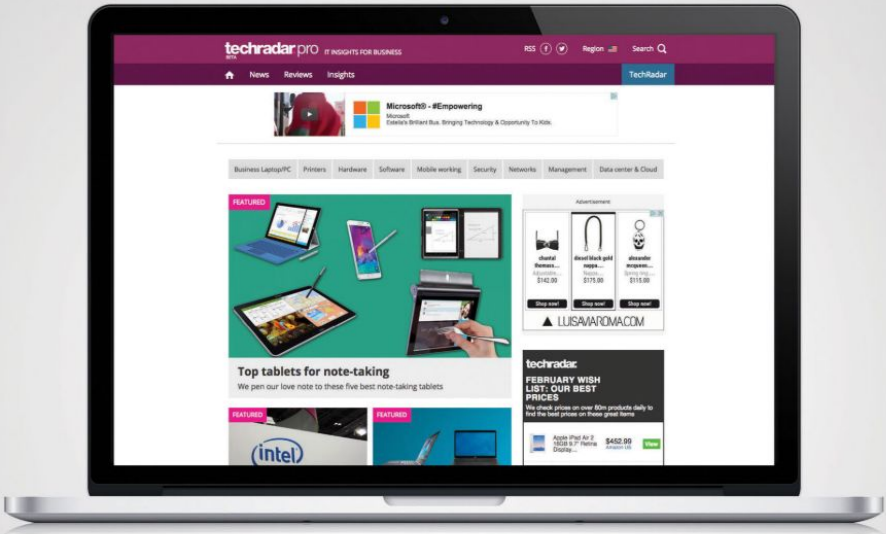

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combination in theory. In practice, monitors based on the panel have yet to be announced. So, details such as pricing aren't clear. However, AUO has a track record of undercutting its competitors in terms of cost. Here's hoping for a 32-inch 4K 144Hz OLED monitor for under $2,000 by the end of 2021.

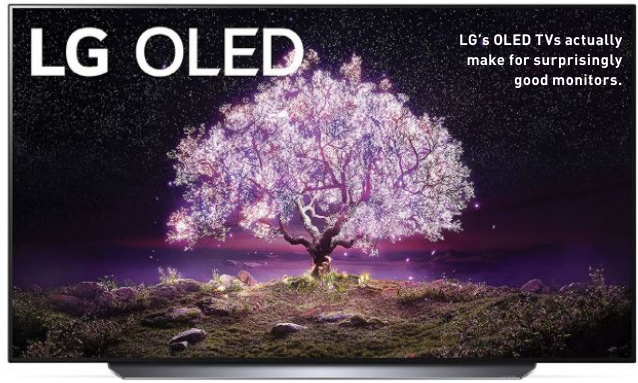
Ironically, the most affordable OLED monitor yet will probably turn out to be a TV. Already, several LG OLED TVs have been adopted by the PC gaming community as large-scale gaming screens. The LG CX and C1 have proven very popular thanks to sub-$1,500 pricing and a combination of 4K resolution, 120Hz refresh, and OLED's characteristically super-fast response. The catch is that the smallest panel size available thus far has been 48 inches. Not only is that ergonomically problematic for a desktop monitor, it also makes for a disappointing pixel pitch of just under 100 dpi. Yuck.

Happily, that's set to change very soon. LG has announced plans to introduce a new 42-inch class of OLED panel later this year that will both be more suitable in terms of size and should also be cheaper than existing 48-inch OLEDs. A 42-inch, 120Hz, 4K OLED display for around $1,000? Sounds good to us. Granted, it won't strictly be a PC monitor, but with features such as low input lag mode with minimal image processing, LG's latest OLED TVs have proved remarkably well optimized for use as a desktop monitor.

Back in the mainstream, a new sweet spot is emerging in mid-market monitors that combines a decent IPS or VA 4K 32-inch panel with 120Hz or 144Hz refresh. Admittedly, high refresh rates have largely been the purview of gaming monitors. There's certainly little to no benefit outside of gaming in going well beyond 144Hz. A 360Hz productivity panel? That would be very silly. But in terms of making desktop computing feel slicker and more responsive, 120Hz to 144Hz is a nice little upgrade.

Is it worth spending megabucks on a general-purpose display? No. Which is why, somewhat incongruously, the latest 4K 120Hz games consoles from Microsoft and Sony are coming in handy. Put simply, the gaming console market is particularly sensitive, placing a downward pressure on relevant peripherals, including screens. And so a new generation of monitors aimed at those consoles is good news for all PC enthusiasts.

By the end of 2021, several console-friendly 32-inch 4K monitors with circa 120Hz refresh capability will be available



LG's OLED TVs actually make for surprisingly good monitors.

© LG

IS OLED REALLY ALL THAT?

THE TECH WE'VE BEEN WAITING FOR...

The prospect of OLED panels on the desktop has tantalized PC enthusiasts for the better part of a decade. It now looks like OLED is going to make the transition from HDTV to desktop monitor, but is OLED really all that?

For sure, it brings huge advances over LCD tech. OLED's defining advantage is per-pixel lighting—each pixel is its own light source, creating the possibility for total precision when it comes to contrast and dynamic range. With OLED, you can have a single pixel running at full brightness next to one completely switched off and outputting no light at all.

Even the latest LCD panels with mini-LED backlights don't come close in that regard. Even with thousands of dimming zones, the net result is still tens of thousands of pixels sharing a single zone. And that means the dreaded blooming around small and bright objects, including white text on dark backgrounds, is inevitable.

Of course, OLED has several other upsides, too. As a self-emissive tech, it has better viewing angles than transmissive LCD panels. OLED is much faster, too. Independent testing has proven that full on-off OLED pixel response is measured in fractions of a millisecond. Even the fastest LCD panels take several milliseconds to achieve on-off response, as opposed to partial gray-to-gray response.

However, OLED isn't superior by every metric. LED-backlit LCD panels, for instance, can achieve much higher peak brightness. The brightest LED TVs can hit nearly 2,000 nits, while even the latest generation of OLED tech can't even achieve 1,000 nits. And that's peak brightness in isolated hotspots. If it's full-panel brightness you want, OLED tops out below 200 nits.

In the real world, every pixel running full white isn't terribly relevant. But the brighter the overall scene being displayed, the more OLED panel brightness drops off. And that's a real problem when it comes to HDR rendering.

It all comes down to the way HDR content is processed for output to take into account the abilities and limitations of human vision. Known as Perceptual Quantization, or PQ for short, this transfer function includes a model of the granularity of human sight or the ability of the human eye to perceive two different levels of light.

To cut a long and technical story short, an overly bright display can cause the degradation of what should be smooth color transitions or gradients into blocks or bands of abrupt color changes. If the display is too dim, details in bright areas bloom or bleed into one another, resulting in the loss of finer elements as large areas flatten out and become featureless. Anyway, in brighter HDR scenes, OLED technology lacks detail compared to the best LCD panels.

OLED's other obvious weakness involves burn-in. That's a problem thanks to differential degradation within the RGB subpixels. The blue subpixels wear out faster than the red and green subpixels, leading to color drift that manifests as permanent image burn-in. Yuck. It's not a huge problem for video, with constantly changing images, but Windows, with its persistent taskbar, menus, and the rest, is prone to generating screen burn-in on OLED displays.

for perhaps as little as $500. They'll be 32-inch because that slightly larger format is more suitable for gaming than 27-inch. Which again represents a welcome fringe benefit in a productivity context, thanks to the additional space it provides for viewing multiple documents and application windows in parallel. What's more, because gaming monitors increasingly need to deliver at least basic HDR performance (note these aren't fancy mini-LED monitors, which is part of the reason why they should be competitively priced), color accuracy should be good enough for most workflows, albeit you'll still need a proper pro display for really serious content creation.

Examples of this new affordable 32-inch, 4K, 120Hz-plus brigade include the Philips 328M1R and 329M1RV with VA and IPS panels respectively, the ViewSonic ELITE XG320U with HDR600 and an IPS panel, and the HDR400 and IPS-equipped AOC Agon AG324UX. The way things are currently going with crazy prices attached to everything from puppies to Porsches, of course, we may all have to wait just a little bit for prices of this class of panel to hit that $500 marker. But that's roughly what we're expecting in the medium term.

If those are the most intriguing trends regarding the screen tech coming to the desktop monitor market, what about the stuff that probably won't show up any time soon? The most notable absentee is the wider availability of really high-resolution panels. The 32-inch 6K panel seen in Apple's Pro Display XDR is thought to be produced by—yes, you guessed it—LG, and would make a great basis for a high-end but still much more affordable PC monitor shorn of details such as the megabucks Apple chassis and mini-LED backlight. But thus far it has yet to appear in any other monitor. Rumor has it Apple has secured exclusive access for now.

Thinking about an 8K TV as a PC monitor? You'll need one of AMD or Nvidia's latest GPUs.

Of course, the next big step in terms of resolution ought to be 8K. Like OLED panels in desktop monitors, 8K monitors have been available for several years, including the Dell UP3218K. As yet, however, there's little to no indication 8K is set to go mainstream at anything like the pace that 4K did in the mid-2010s. As an example, ViewSonic has a new 8K panel that's due any day now, the VP3268-8K. But it's expected to land at $5,000. Yup, that's even more expensive than the $3,999 Dell asks for the UP3218K. Moreover, none of the big players in actual LCD panel production, as opposed to complete monitor manufacture, have announced anything that looks like a cheaper 8K option.

If there is hope for affordable 8K desktop monitors, it comes from that same source as the first really affordable 4K screens, namely the HDTV market. 8K is beginning to enter the mainstream in terms of HDTV pricing, with sets from big brands such as Samsung and LG occasionally dipping below $1,000. Now, HDTVs are not PC monitors. In fact, in the early days of big flat-panel TVs, they made for very poor PC monitors.

There's a long list of reasons for that, including ergonomics, picture quality, pixel pitch, lag, and more. But with the advent of 4K, plus features such as low

The Philips 328M1R is one of a new class of relatively affordable 32-inch 4K high refresh panels.

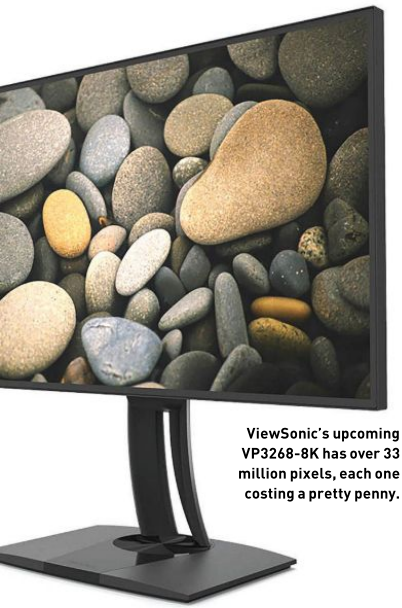
Dell's mini-LED monitor packs two thousand dimming zones.

© DELL, NVIDIA, PHILIPS, VIEWSONIC

input lag modes with minimal image processing, HDTVs have become viable as PC monitors. As we mentioned, if you want an OLED panel on the desktop, it's the only vaguely affordable option today.

Shift the context to 8K and the immediate problem is bandwidth. 8K is four times the pixel count of 4K, some 33.2 million pixels, and 16 times the resolution of 1080p. That requires epic bandwidth. Both DisplayPort 1.4 and HDMI 2.1 are capable of driving a display at 8K 60Hz. DisplayPort isn't a common feature on TVs, so HDMI 2.1 is the interface of choice in this context. Unfortunately, that means forking out for an Nvidia RTX 30 series or AMD Radeon RX 6000 graphics card, the only GPUs with HDMI 2.1 support. If you can find one to buy, that is.

If you can, does an 8K TV as PC monitor actually make any sense? Well, it's not something we've tested. However, it's worth noting that a 55-inch 8K TV, currently the smallest available, has about the same pixel density of 160 dpi as a 27-inch 4K monitor, and significantly better pixel density than a 32-inch 4K panel. Yes, 55 inches will be far too big for many desks, but the basics of the image quality are promising. Should 8K make the step down to the 40-something-inch class of HDTV, that will be seriously interesting. If that does happen, here's hoping GPU prices and availability are back to something even resembling normality in time.



ViewSonic's upcoming VP3268-8K has over 33 million pixels, each one costing a pretty penny.

The USB Type-C interface is seriously slick and simple to use.

GET CONNECTED

USB-C IS ABOUT TO GET EVEN BETTER

Display interfaces are not obviously aspirational or exciting. Certainly, they're critical enablers of good display technology, but we're into the realms of the mundane and functional when it comes to comparing HDMI to DisplayPort, right?

Perhaps. But if there is an exception, a display interface that's so slick and clever it's actually cool, it must be USB Type-C and its Thunderbolt cousin. If you're a laptop user, the ability to plug in a single cable to drive an external display, charge the laptop itself, and also connect peripherals including input devices and external storage is liberating. Slap that notebook down, shove in just one cable, and you're almost instantly good to go. USB-C is far tidier, too. Once you've experienced a USB-C monitor, you won't want to go back to that rats' nest of cables.

If that's all the good stuff, USB-C does have some limitations. The actual bandwidth available varies, which in turn restricts options in terms of things like screen resolution and refresh, plus the bandwidth available to devices such as external hard drives. The other shortcoming is a maximum power delivery of 100 watts, which isn't enough to feed a really powerful laptop PC running under heavy load.

Bandwidth and connectivity-wise, the next step up involves monitors supporting Thunderbolt 4 and USB 4. They'll be backward compatible with existing Thunderbolt 3 and USB-C devices. Ultimately, Thunderbolt 4 and USB 4 are almost the same, the main distinction being that Thunderbolt 4 always delivers fully 40Gb/s of bandwidth while USB 4 has an optional 20Gb/s implementation. Thunderbolt 4 cables supporting that 40Gb/s can be up to two meters long, while Thunderbolt 3 was limited to 0.8 meters at maximum speed.

For context, 4K at 60Hz refresh requires 12.54Gb/s of interface bandwidth while 4K at 120Hz increases that to 25.82Gb/s. So, a Thunderbolt 4 or full-speed USB 4 connection could drive a display at 4K120 and still have nearly 15Gb/s or a little under 2GB/s to spare for peripherals and storage. The real-world usable bandwidth will be a bit less. But even 1GB/s for an external SSD would be decent given the simplicity and convenience of that single-cable solution.

As for power, the USB Implementers Forum recently announced a new Extended Power Range (EPR) definition known as USB-PD R3.1. It increases the maximum power of USB-C charging from 100W to 240W. Plenty for all but a few outlier portable PCs. But that level of power also comes with some specialized requirements.

Sockets and cables supporting EPR will need tweaks to prevent shorting and arcing, especially when unplugging. Part of the solution is to make the CC and VBUS pins different lengths, thereby allowing the detection of disconnect events early enough to enable the power source to reduce current prior to full disconnection. A snubber capacitor at both cable ends is also recommended to help ensure this new upgraded USB-C interface doesn't set sparks flying.

CENTERFOLD

PERFORMANCE GEAR LAID BARE

1 AMOLED DISPLAY

With a 1.2-inch display, packing 360x360 pixels, you'll be surprised to hear this thing packs in a pixel density of 364 ppi. That's as high as most modern smartphones. Combine that with an impressive brightness and color contrast, thanks to that Super AMOLED display, and it's beautiful to behold.

2 BATTERY LIFE

The big question, right? How long does it last? In the configuration we have, we get through around 50 percent every 10 hours. However, that's with the display permanently on, the brightness high, and GPS and heart-rate tracking on continually. Some people have recorded up to four days. There are smartwatch hybrids out there that will give you 32 days off a single charge.

Samsung Galaxy Watch Active2 40mm

TIME IS THE MOST valuable thing we have in our lives. It's finite, fluid, fleeting, and often not appreciated until it's gone. We spend our days working hard, supporting our family and friends, striving for ever greater heights, yet we often forget to spend time on the most important person: ourselves. Helping others is admirable, but it's just as important to look after yourself. You can't support anyone else if you're falling apart at the seams, and yet there's seemingly never enough time in the day to do so. After all, the turning of the world stops for no one.

It's that notion of keeping track of time and spending it more wisely that inspired our editor-in-chief to invest in this device. Technology has the ability to make our lives easier, and this smartwatch can be a key component in helping those saddled with responsibilities to stay on track, and push them back into the world of being both physically and mentally fit.

How far these gadgets have come in the last decade is staggering, and their ability to pull you away from your phone screen, off the couch, and into your sneakers is incredible. Littered with sensors, in a myriad of forms, there's a smartwatch for everyone. For this writer, the Watch Active2 is the best fit; for you, it might be the Apple Watch SE or the Garmin Instinct. There are hundreds to choose from.

It's understandable to be on the fence about these things, holding them in cynical regard—we certainly did—but after spending some time with this one, consider us converts. **–ZAK STOREY**

3 SENSORS & CONNECTIVITY

We're just going to list all the stuff included on this thing: It has an accelerometer, gyroscope, heart-rate sensor, barometer, VO2 Max sensor, and ECG monitor, it can measure blood pressure, track your sleep, has NFC, Bluetooth 5.1, Wi-Fi 802.11b/g/n, GPS (including A-GPS, GLONASS, Galileo, and BDS), and wireless Qi charging, too. Kitchen sink, meet tiny watch.

A PARENT'S GUIDE TO PROGRAMMING

Mike Bedford investigates which languages to consider if you want to help your children get a head start in coding

Let's start with a history lesson. The first high-level languages—which made their debut in the 1950s and included the likes of FORTRAN, ALGOL, and COBOL—were designed as down-to-earth tools with little thought given to education. This changed in 1964 with the introduction of BASIC. The language's acronym hints at its nature, and its full name, Beginners All-Purpose Symbolic Instruction Code, emphasizes its educational credentials. Indeed, BASIC was designed for use by students who had little appreciation of computers. It outlived other languages of that era, having been adopted for use in the home computers of the late '70s and '80s, and helped another generation learn to code.

While BASIC remained largely unchallenged for several decades, if you want to help your children learn to code today, it's not nearly as easy to choose a language. For a start, there are now several other languages that were designed exclusively, or almost so, for education. Also, any discussion of

beginners' languages invariably brings up various languages which, although not originally intended for such, are considered to have a role in education.

We're here to help you navigate your way through the language jungle to decide which would be the best for your children to learn. We consulted Carrie Anne Philbin, director of educator support at the Raspberry Pi Foundation, who also leads on the teach computing curriculum for the UK government-funded National Centre for Computing Education (NCCE), and she provided some useful insight into the various languages we consider here. Her opening remark is worthy of our attention. "I guess the most important information I can impart is that in education—both formal and non-formal—we do not start with a programming language," she explained. "We always start with concepts, usually offline, before using tools that help learners make the concept more concrete in their minds."

SCRATCH

If you've not delved into educational languages before, it's possible you've not encountered block-based languages. In passing, that term is entirely different from block-structured, the concept that's key to structured programming and inherent in most of today's programming languages. By way of contrast, a block-based language involves programming by dragging blocks—which we can think of as statements—from a palette on to the scripting area, and editing by manipulating those blocks in the scripting area. In other words, it needs little in the way of free-form typing, the requirement being pretty much limited to editing things such as the time in a wait block or the distance in a move block. Ease of use is also enhanced by virtue of the blocks being shaped somewhat like jigsaw pieces, an approach that slightly reduces the possibility of using a block in a nonsensical context.

Scratch is our first block-based language—it's free, multi-platform, and open source, and it was developed by MIT's Media Lab. Scratch is the block-based language primarily recommended by Carrie Anne Philbin, who suggests that it's suitable until a transition to text-based languages, typically at age 11 to 13, although for ages five to seven, the closely related Scratch Jr. should be the language of choice. Scratch is used in formal education, as well as in non-formal education in homes, and in after-school clubs, such as Code Club and CoderDojo.

You can install Scratch locally or run it online at https://scratch.mit.edu. However, Scratch Jr. is only available as an app, intended for use on tablets, and is available for iPads and Android devices.

Its block-based approach might be unfamiliar to experienced programmers, but Scratch is highly recommended as a first language.

BLOCKLY

Developed and hosted by Google, Blockly is our second block-based language and, although it's sometimes thought of as such, it appears that its developers didn't design it exclusively for educational use. This being the case, it's probably not too surprising that it's less basic than Scratch and, therefore, suitable for creating real applications. Indeed, while we trust that the statement doesn't consider educational resources as toys, Google specifically says "it's not a toy" and you can use it to "implement complex programming

Bee-Bot and Blue-Bot

For especially young children, even those for whom using a block-based language might be a step too far, Bee-Bot ($90) or Blue-Bot ($120) might be of interest. Referred to as programmable floor robots, and typically used with mats that the robots can be programmed to navigate, these devices don't have to be programmed via a language at all. Instead, they can be programmed by pressing buttons on the robot's body. So, for example, if you press the "Clear" button, followed by "Forward" twice, "Right turn," "Forward," and "Go," the robot moves forward by 300mm (2x 150mm), turns right 90 degrees, and finally moves forward by 150mm, with a short pause between each step. While this isn't programming as we normally use the word, it is, of course, exactly that, and it teaches some key principles.

Turning to Blue-Bot, you can use this in the same way as Bee-Bot, but there's more. First, it's transparent, so inquiring minds can get a feel for the hardware that controls it, but more importantly, it has a Bluetooth interface. This enables kids to progress to controlling the robot remotely from a handheld device, albeit only Windows, iPad, or Android. To cut a long story short—and it does more—the free app makes it possible for kids to create a program on screen via a simple process, download it to Blue-Bot, and execute it.

Bee-Bot offers young kids a fun way to program a robot by pressing the various buttons on its body.

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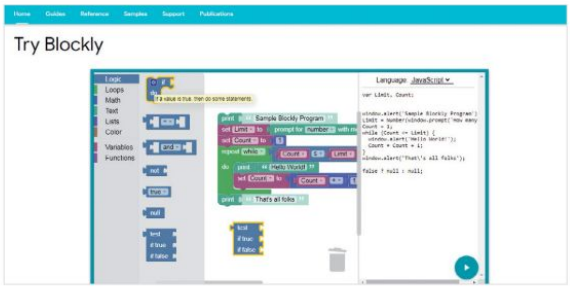


Google's Blockly is block-based, but it can be used for creating real applications. As an educational language, it's more suited for older kids than Scratch.

tasks." Despite being developed by Google, Blockly is an open-source project.

According to Carrie Anne, Scratch dominates the block-based sector, so Blockly is used when it has to be, for example when programming in App Inventor (https://appinventor.mit.edu), or with the micro:bit single-board computer, where Scratch wasn't supported at first. We were also told that Blockly is closer in design to a text-based language. For that reason, it's suitable for older children between the ages of 10 and 14, and it's not recommended for young ages.

Blockly runs in a browser from https://developers.google.com/blockly and it offers the interesting feature of generating and displaying the code in a range of text-based languages—specifically JavaScript, Python, PHP, Lua, and Dart—that correspond to the block-based code. We can imagine that this could have some value in the process of migrating from a block-based to a text-based language. While Python and JavaScript are obvious choices in this respect, Lua and Dart might be somewhat surprising. Although Scratch and Blockly aren't the only block-based languages, they're the ones we hear most of by far in education.

Now we'll turn our attention to the text-based languages that most of us are more familiar with.

BASIC-256

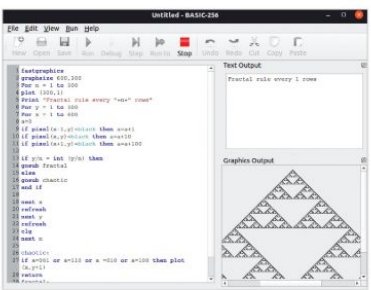
Given that it's 56 years old, has missed out on many of the more recent programming paradigms, and it draws some criticism, we were unsure whether we should include BASIC. However, since it's still used professionally, albeit in its guise of Visual Basic, and it still gets recommendations as a language for kids, it's appropriate to consider it here. As perhaps the most commonly cited modern(-ish) implementation for educational use, it's BASIC-256 that we're looking at. Unlike the original BASIC command-line implementations, this version takes the form of an integrated development environment (IDE), with windows for the code, textual output, and graphical output.

This version of BASIC was developed in 2007 specifically for teaching programming. Like BASIC of old, but unlike some of the more recent versions, flow control is pretty much limited to GOTO, GOSUB, FOR...NEXT, and IF...THEN...ELSE...ENDIF. While this contributes to its simplicity, this is the source of some criticism. It's argued that it doesn't teach the principles of structured programming, instead promoting "spaghetti code." To counter this, many people have said that they learned to program in BASIC and it didn't prevent them having a successful career in software engineering, using a range of languages.

In light of this, we elicited the view of Carrie Anne who, while not giving a specific answer to our question of whether it has any place in education today, said that BASIC isn't a common choice anymore, while also stressing her earlier comment about the basic principles coming before tools: "Learners are taught concepts first, not languages. Concepts can be applied to any language, so the next choice is based on what is freely available and comes with access to resources and support."

LOGO

Another educational language that isn't exactly a newcomer is Logo. There are several versions that



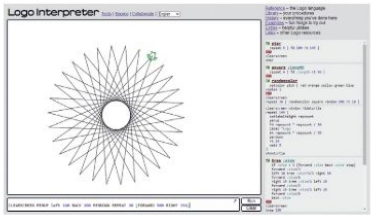
BASIC certainly has its critics but, despite the controversy, the BASIC-256 dialect is being promoted for educational use.

© GOOGLE, BASIC-256

Sonic Pi

Sonic Pi (https://sonic-pi.net) is described as a code-based music creation and performance tool. The tool runs under Raspberry Pi OS (it was developed in conjunction with the Raspberry Pi Foundation), as well as Windows and macOS. It's also referred to as a live coding environment. This means that performers write code on the fly to create music as they're performing. We might think of it as enabling a digital jam session. Where things differ, though, is that it's common to project the live code on to a screen during performances, so the audience can share in the coding experience.

It's used by professional artists, but it also has educational value, especially for kids. According to its developer, Sam Aaron, writing for *MagPi* magazine, "Sonic Pi was conceived and built within classrooms in close collaboration with teachers and has benefited from many design iterations based on hundreds of hours of student observation. Simplicity has even been baked into the core design philosophy by only allowing features that may be easily understood by and taught to a 10-year-old." And while this hints at its simplicity, it's based on the Ruby programming language, so the sky's the limit.



Despite being long in the tooth, Logo still has its fans and, if you consider only its "turtle" instructions, it might be ideal as a first text-based language for kids.

run locally, UCBLogo being well respected, and it can also be accessed online, for example at www.transum.org/software/Logo and www.calormen.com/jslogo. Logo is a full-featured programming language, and is described as "multi-paradigm," although its use in education has tended to concentrate on just one element of the language. This is the "turtle" functionality that controls the movement of a so-called turtle, drawing its path on the screen, and thereby producing a graphical output.

Given that there are only a few turtle statements, Logo offers a simple introduction to text-based programming and could be a first step beyond the block-based approach, perhaps for kids much younger than 11, which is the recommended age for starting with text-based languages. What's more, programming to create a graphic output appeals to young minds.

However, we had nagging doubts about why it receives less attention than it did a few decades ago. Might this be because more modern languages are much better suited to its particular niche? Carrie Anne was certainly enthusiastic about the use of turtles. "The use of turtles is very common in programming education," she suggested, "from using Bee-Bots in elementary schools to understand sequence and algorithms, to building Raspberry Pi robot buggies in high school to solve more complex mazes."

PYTHON

With our next language, we progress from those that were designed first and foremost for education to general-purpose languages. As today's third most commonly used language, that reason alone might be enough to guarantee it a place in education, but there's more. In particular, Python is commonly recommended for educational use—and, in particular, as a first text-based language—primarily because it's much simpler to learn than many other languages.

Carrie Anne suggested that ease of use isn't the only factor in its prevalence in education. Other reasons for the popularity of Python include the fact that it's free, cross-platform, and open source. She also pointed out the many IDEs that have been developed over the years, which meet the needs of education, such as Mu (https://codewith.mu—described as a simple Python editor for beginner programmers) and trinket (https://trinket.io, which is browser-based). Resources for teachers are also important, leading to its use in schools and therefore underlining Python's suitability for home learning. "At the NCCE, much of our professional development is based on Python," she said, "which means, in turn, they're likely to use it as their text-based language in the classroom." Building on this theme, she also referred to the fact that other resources to help teachers are overwhelmingly built around this language and are often freely accessible, such as the Raspberry Pi projects (https://projects.raspberrypi.org/en). Python is considered suitable for ages 11 and older.

C++

In industry, C++ is still commonly used. In fact, it's just one position behind Python in the well-respected TIOBE index (a body that assesses the quality of software coding), in fourth position. This is one of the reasons it's recommended as a suitable language for use in education. After all, if it's so commonly used, it's argued, a knowledge of C++ will provide students with good job prospects or a good grounding for further education.

Another plus point, according to some educationalists, is that it provides students with a good understanding of how computers work, because it's a much lower-level language than most of the other languages promoted for use in education, in the sense of being just one step up from assembly code.

OTHER LANGUAGES

While we've probably covered the programming languages that are most commonly used in education, they aren't the only ones. A brief mention of a few alternatives is appropriate—indeed, Carrie Anne mentioned a couple.

Her first suggestion is probably somewhat surprising, since the language is only in fourteenth place in the TIOBE index. However, it has to be admitted that it's necessarily a show-stopper in education since, for example, Scratch is down at position 21. "Ruby is becoming more popular in education. Sonic Pi is a good example of an accessible tool that helps you code music, which is also used to help teach programming concepts to young people, based on Ruby. It's accessible as a language, while its simple syntax makes it more accessible to young people," she said.

To conclude, we feel compelled to reiterate Carrie Anne's view that understanding concepts is actually more important than learning specific languages. This being the case, in addition to considering the pros and cons of the various languages that we've presented, and making sure you don't introduce your kids to languages that aren't appropriate for their age, it's also valid to think about what languages you feel confident to teach. Even so, if you've recently been employed maintaining legacy systems, so you're up to speed with vintage languages, we're really not too sure that teaching COBOL to your five-year old would be the wisest approach.

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DISCOVER THE ALTERNATIVE TO APPLE AND WINDOWS

This is a treasure-trove of Linux and open source knowledge, from the evolution of Ubuntu and its mobile platform, to projects like automating your home with Raspberry Pi.

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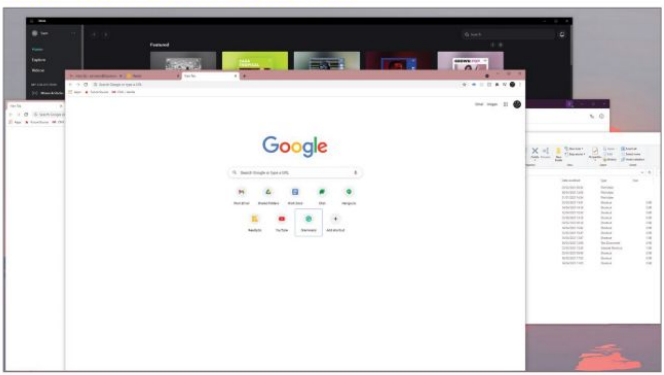
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



AERO SHAKE

Your open tabs can get piled on top of each other in no time at all when you're deep in a project or flicking between applications. One elaborately named action you can perform is to "Aero Shake" them away. Instead of clicking the minimize buttons one by one, simply click and hold on any window bar, then shake it from side to side until all the other windows rapidly collapse. Quick, efficient, and with a name we like.

MAKE – USE – CREATE

60
Create surreal spherical art with Photoshop

62
Build yourself a better liquid-cooled setup

68
Step by step guide to building our pseudo retro rig

© MICROSOFT, ADOBE

SAM LEWIS
STAFF WRITER

STRESSES AND STRAINS

I must confess, I planned to fix a charging issue in my retro-fitted CarPlay this month, but that endeavor has come to a standstill. Instead, I turned my attention to my first PC build, and to say it wasn't stressful would be a lie. Every step resulted in me digging into the Internet looking at how to install the next component. Let's put it this way: I thought it would be easier than it was, but now that I've done it, I can safely say I'm looking forward to my next build.

The project was stressful in another area, too: The courier caused me to miss my collection time, and I had to drive for four and a half hours to drop the PC off at the photography studio. I then had to unbuild it step by step, with help from photographer Olly and editor Zak, and build it again when I got home. Sure, it gave me lots of PC building experience in a very short time frame, but I could have done without the stress.

Skip forward only a few weeks and I had to strip it once again due to some of the components being requested back and other parts needed again for photography purposes. Thankfully, I managed to take the bits out and package them in time for collection this time around. This month has opened my eyes up even more to PC building and the customization side of computer hardware.

↘ submit your How To project idea to: editor@maximumpc.com

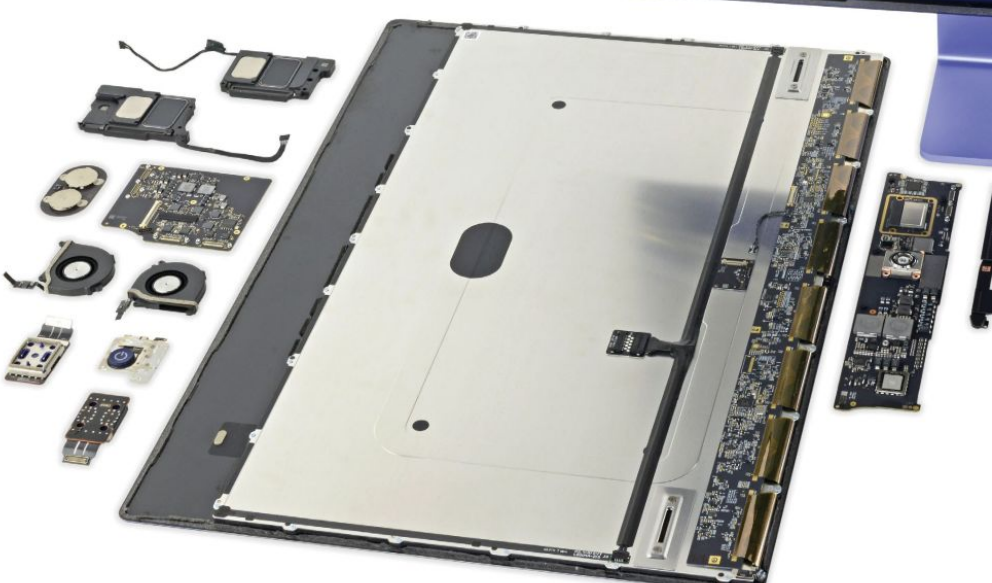
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

iMac M1 24"

Like past iMacs, the logo has a cutout that acts as a convenient window for a patch antenna.



You can have this teardown in any color you want, so long as it's purple.

Quirky, colorful, and bold—we like it, Apple.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
To learn more, visit www.ifixit.com.

BACKGROUND

Is the new M1 iMac just a silly-sized M1 iPad, a detached-keyboard M1 MacBook, or an M1 Mac Mini stretched out like pizza dough? We'll only know by getting inside, however tough that might be. It's time for a teardown of the mid-tier model.

MAJOR TECH SPECS

- Apple M1 chip with eight-core CPU (four performance cores and four efficiency cores) and 16-core Neural Engine
- Apple M1 integrated eight-core GPU
- 8GB of unified memory
- 23.5-inch (diagonal) True Tone display with 4480×2520 resolution and support for one billion colors (P3 color gamut)
- 256GB of SSD storage

KEY FINDINGS

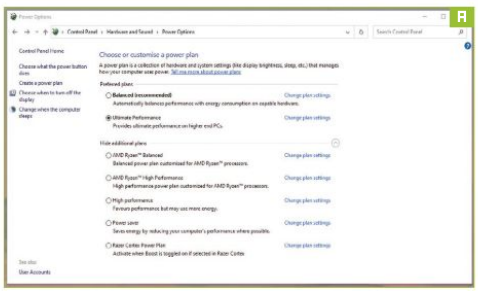
- Specs aside, at first glance this iMac looks like an iPad on a stand. We've been doing iMac teardowns for a long time, so we're fairly quick by now, but if you're impatient, nothing beats an X-ray. Compared to an X-ray of the 27-inch Intel iMac, we noticed a few things. The new iMac's interior is dominated by two huge metal plates. What are those for? The Apple logo provides a convenient RF pass-through for antenna hardware. Almost all the silicon is concentrated into narrow horizontal strips at the top (display board) and bottom (main logic board).
- Our mid-range unit comes with two Thunderbolt 4 ports and two regular USB-C ports. That's double the base model, but not much for a desktop. The M1 iMac is two iPads thin—not deep enough for a headphone jack, so it turns its jack sideways to fit.
- The M1 iMac still uses the classic iMac adhesive, so it's not quite the goopy iPad nightmare that we feared. It's not all familiar, though. This M1 is actively cooled by a pair of fans, the first M1 iMac to feature more than one. Each fan blows inward across the logic board, where the heatsink draws heat away from the M1 with a copper heat pipe and two short heatsinks.
- If you guessed that those shiny metal chambers were part of the speaker system, you were right. They're impossibly thin (about 1.5mm at the opening), but their sprawling surface area equates to a large volume, thus more air and fuller sound.
- What else can we shake out of this iMacPad? First we find a modular headphone jack—good news, considering this could be the port that sees the most action. The chassis's thinness does have a silver lining: The headphone jack isn't on the back. There is a power button, too, on a sturdy metal bracket, which is glued to the enclosure. It actuates on a little hinge. Also found is a "studio-quality" triple-microphone array.
- The display shield features two horizontal slots that hang on corresponding tabs in the case, keeping the display securely mounted. The stand's hinge hardware is no longer accessible from outside, so choose VESA. The newest iMac follows other M1 machines down an interesting but even-less-repairable path. A lot of impressive engineering went into making it as thin as possible, but did anyone need a thinner all-in-one desktop?
- Repairability Score: 2 out of 10 (10 is easiest to repair). The fans, USB ports, headphone jack, power button, speakers, and webcam are all reasonably modular and fixable in a pinch. The external power supply is trivial to replace, but very difficult to service. The display is tedious to remove and replace, but is the most accessible component. There's no altering the internal storage at all. Memory is soldered to the M1 package, making it impractical to replace or upgrade. The only path of entry is through the display adhesive, making all repairs tedious.

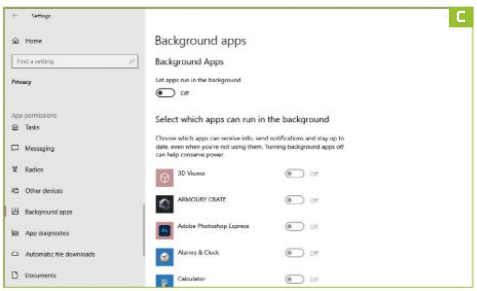
Amp Up Your Frame Rate in Game

YOU'LL NEED THIS

RAZER CORTEX
Download for free from www.razer.com.

EVERYBODY AND THEIR DOG wants to get the most out of their PC. Speed is key, and it's a waste if you've got a rig that isn't giving you all it can. There's always overclocking, but if you don't want to disappear down that rabbit hole just yet, we have a few things you can do to your build that should help get things running a little more smoothly. If nothing else, you will get a little peace of mind knowing you have tried these tips, but hopefully you will see increased performance and be able to crank up some game settings. Every little counts here, especially when it comes to competitive gaming. –SAM LEWIS



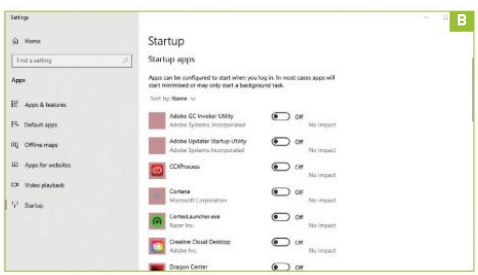


1 ENABLE ULTIMATE PERFORMANCE

One of the first things you can do to help speed up your PC or laptop's performance is to check what power plan you are running. Head to "Control Panel → Hardware and Sound → Power Options." This should show a list of preset power plans. To see all available options, click the drop-down arrow labeled "Show additional plans," and make sure you are running your PC on the "Ultimate performance" option [**Image A**]. If using a laptop, ensure you are plugged in when using this setting, otherwise your battery life will be no better than that of an iPhone 4. Yikes. Switch back over to "Balanced" when unplugged to preserve your battery life.

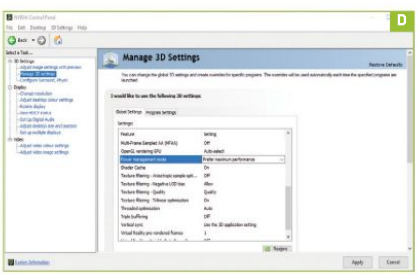
2 DISABLE STARTUP APPS

Sure, startup apps can be beneficial when you boot up your PC in the morning—you don't have to mess around opening them all up, and it allows you time to get a cup of hot joe. However, if you head into your settings and search for "startup," you will probably notice that there are a whole lot of apps there that you don't use on a regular basis, which are opening up, making your taskbar an eyesore, and hogging precious CPU cycles. You don't want these clogging up your PC, so turn off what you don't need [**Image B**]—it will help keep your PC tidy, too.



3 DISABLE BACKGROUND APPS

Similar to the previous step, there are often things running behind the scenes that you don't know about, even if you haven't technically opened the application. Apps running in the background are useful, especially if they provide you with important information and notifications, but with enough of them lurking in the shadows, they can hinder your PC's performance. Head to your PC's settings, then go into the "Privacy" section and find the "Background apps" list [**Image C**]. You can manually toggle specific apps on or off, but if you want,



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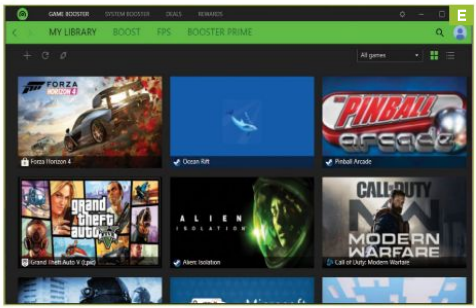


you can give background apps the big middle finger, and hit the kill switch to put a stop to all of them.

4 NVIDIA 3D SETTINGS

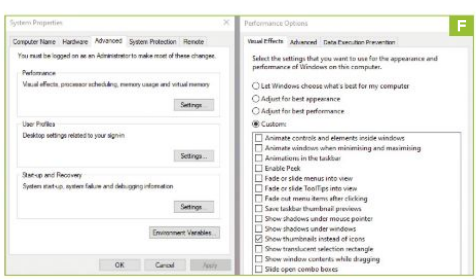
Instead of heading into the Windows Control Panel, we need to dive into Nvidia's control panel (if you're running an Nvidia GPU). You will see a panel on the left with three options: "3D Settings," "Display," and "Video." Under "3D Settings," go into "Manage 3D Settings," and you will see a long list of options. The ones we need to change are "Power management mode" and "Texture filtering quality" [**Image D**]. Change "Power management mode" to "Prefer maximum performance," and change "Texture filtering quality" to "High performance." You may worry that you might get a slightly fuzzier image, but there's no noticeable difference. If you can see a difference, simply change it back. All these tips are reversible, so see if they work for you, and if they do, stick with them to get more juice.

5 RAZER CORTEX

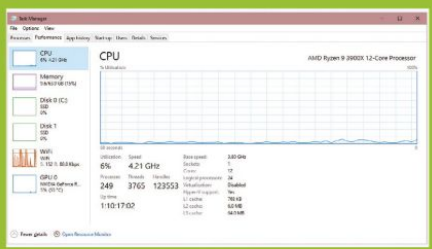
When trying to increase PC performance, doing it without having to spend money is always a good thing, so being able to download free software to amp up your gaming is great. Razer Cortex (www.razer.com) is a very simple game launcher that does all the hard work for you. The app manages and stops non-essential processes and apps to produce a smoother gaming experience. It features a library that organizes all of your titles, a settings booster, a PC cleaner, and information about your setup. To help with games, you need to go into the "Boost" section in the green window [**Image E**], and select "Auto-boost." This automatically runs a system boost whenever launching a game—pretty handy, especially for free.

6 SYSTEM PROPERTIES

Once again, you need to start in the settings, so in the search bar type "about PC." On the "About" page, scroll down to the bottom and click the option that says "Advanced system settings." This opens up a new window. In the "Performance" section, click the "Settings" button. Again, this opens another window, where you can toggle various visual performance settings on or off [**Image F**]. We all like visual effects, but if you can sacrifice some fancy shadows and animations for better performance, which path are you taking? For us, we chose the "Custom" option, and kept "Smooth edges of screen fonts" selected, and also "Show thumbnails instead of icons." What you choose is up to you—if you want to have specific visual effects left on, keep them, but the fewer you have checked, the better performance you will have.



TASK MANAGER



The Task Manager is an advanced tool built into Windows 10. This handy piece of software provides lots of information about how your PC is running and behaving. Details found in the app may be able to help you find the cause of an issue you are experiencing. It monitors the software, processes, and services running on your computer, displaying the data in real-time graphs.

At the top of the window, you can see a "Processes" tab. If it feels as though something is dragging the performance of your PC down, this should be one of the first places to look. The "Processes" tab shows you which applications are running and which pieces of hardware are being affected. To see which components are being impacted the most, click on "Processes," and it shows you how much of your resources each application is using. This shows at a glance whether a particular application or game is taking its toll on your CPU, GPU, and so on, and how much of their resources the app or game is using.

In the "Performance" tab, you can see a lot of technical information about your PC, including your CPU, memory, disk information, Wi-Fi data, and GPU. This is very handy for seeing if your speeds are up to scratch. You can look at your CPU's speed, for example, with a live data chart of how it's performing. In a way, you can think of the chart like a car on a dyno. If the car is pushed harder and increases its performance, the bar graph spikes, displays all the speeds, and shows you how linear the growth is. It's exactly the same for your PC's speed.

So, if you have a problem, before panicking, check out the Task Manager, look at how your PC is running, go to the "Processes" tab, and find the culprit. From there you can decide what to do—whether to re-install that application, update it, or uninstall it to help the performance of your PC.

Create Surreal Spherical Art

YOU'LL NEED THIS

ADOBE PHOTOSHOP CC 2018 ONWARD
To view compatibility visit: https://helpx.adobe.com/photoshop/system-requirements.html.

PHOTOSHOP CAN BE very aptly described as a tool for your imagination. If you can visualize something artistic or creative in your brain in the first place, chances are you can transform that concept into a reality using Adobe's software. So, when you picture all those crazy illustrations in your head, don't just disregard them in the belief that they would be too difficult to recreate. Give them a chance and take your time; Rome wasn't built in a day. Don't quote us on that, though—we aren't historians.

The specific form of surrealist art we are focusing on this issue is spherical art. You may have seen this type of bizarre artwork plastered all over the Internet and wondered how it is made. The spherical glass ball we are creating is a perfect way to spice up landscape shots and create something attention-grabbing. It could look great on posters, album covers, flyers, you name it. A few simple Photoshop tools, shading, and filter effects are all that's needed to create this surreal 3D art. –SAM LEWIS

1 PICK YOUR PICTURE

As usual, we're using an excellent license-free image website called Unsplash for our base shot. Unsplash showcases tons of free images that you can use free of charge in your projects. The photograph we selected comes from Diego Jimenez and is a beautiful shot of the Atacama Desert in Chile. The more attention-grabbing the original image is, the better the end result. The spherical glass effect emphasizes what is already there, so make sure your base image has plenty of character.

›› Like all tutorials, there are a few essential things to do before diving into the deep end. Organization is key for efficient workflow; Photoshop can easily get messy and overwhelming if you aren't tidy with your document. We need to open up this image in Photoshop, rename it and the layers appropriately, and make a locked copy of the background image for peace of mind. Press Ctrl-R to bring up the ruler guide, then drag horizontal and vertical guidelines to create a center point of your image, as seen in our example. These should snap into place to create the middle lines.

2 CIRCLE TIME

Now we're ready to create our visually captivating masterpiece; move over, Picasso. Head over to the left-hand tool panels, and select the ellipse shape tool to create a circle in the middle of your image. When drawing your circle, start from the center point we created a second ago, and hold Shift and Alt together to create a perfect circle. Scale this to the desired size of your glass sphere. This should automatically be filled in black (the default foreground color [Image A].

3 SPHERE OF INFLUENCE

This is where stuff gets juicier. Bring the unlocked layer of the original landscape image to the top and go to the filters. In the "Filter" window, go to "Distort," then "Spherize." Make sure it's set at 100% and click "OK." You can repeat this process to make it more spherical, but each time this is done it reduces the quality, so don't do it too many times or you'll end up with a *Minecraft*-esque poster.

›› Once this is done, press Ctrl-T to scale the sphere image. You want this to be the same size as the circle you created earlier. You need to scale it non-proportionally; hold Shift to make it snap to the edges of the circle shape so that it is perfectly aligned, as shown in our screenshot below [Image B].

4 MASKED BALL

Now for some masking. First, load the selection of the circle shape. While on the spherized layer, click the thumbnail of the shape while holding Ctrl to make a selection. Then, click the layer mask button

© ADOBE

C

below the layers to trim away the corners of the spherized image. Turn the visibility of the shape layer off to get rid of any thin black lines around the sphere.

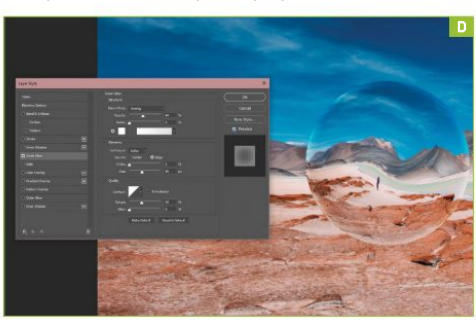
›› Next, we can make the shape a little more abstract by adding a twirl distort effect. In the masked layer, click the left thumbnail to select that layer. Then, while holding Ctrl, click the circle thumbnail again to make that selection. Go to the "Filter" window, and select "Distort," then "Twirl." Then go to "View → Show → Guides" to make it easier to see the effect.

5 SHADY BUSINESS

Now we need to create more of a 3D effect using shading. Create a new layer and name it "Shading." Click the brush tool and set up a brush with zero hardness. Once this is done, click the black circle layer thumbnail while holding Ctrl to make the selection, then draw around the edges of the circle lightly in black and white to create a 3D effect. Increase the brush size and use the edge of the brush tool circle to gently add definition to the circle [**Image C**].

6 GLOW AHEAD

To further emphasize the 3D effect, we will change the blending effect and add a little inner glow. First off, make sure you are on the spherized layer. Above the "Layer" tab, you should see a drop-down box that says "Normal." Click this and change the blending mode to "Soft light." This should make your shading less harsh, creating a more natural blend on the glass sphere. Then drop the opacity of this layer to a percentage that best suits your image; for ours, we have dropped the opacity down to 35%. For the inner glow, you need to select the thumbnail of the sphere layer, then click the "FX" button at the bottom of the right-hand side. Open the inner glow effect, and now we can start adding some more shading and highlights.


D

UNSPLASH

If you've been following our tutorials for a while, you may have picked up on a particular website we use for finding free licensed imagery. Unsplash (**https://unsplash.com**) is great for a variety of projects; whether you're a graphic designer, photographer, artist, or content creator, it's a convenient hub for finding images to complement your work. One of its main tenets, displayed on the homepage, is that it is "powered by creators everywhere." The images are available to download in various sizes, including small, medium, large, and original, the latter being the highest resolution option.

The site's licensing rules are: All photos can be downloaded and used for free; they can be used for commercial and non-commercial purposes; and no permission is needed (though attribution is appreciated). Compared to other image libraries (paid licensing sites), this suits creatives for the ease of use it offers, and carries no licensing worries, for peace of mind. There are only two things to consider: Photos cannot be sold without significant modification, and compiling photos from Unsplash to replicate a similar or competing service is not permitted.

As well as downloading images for your own personal usage, you also can upload your own imagery, which could be a great gateway to building your own photography portfolio. The website is very easy to use and navigate, with a search bar sitting at the top of the site, and all the categories of images sitting below that. It's a great place to come for inspiration or even update your desktop with some hi-res wallpapers. If you haven't checked it out before, we are sure you can find a use for it. Why not use it for perfecting your Photoshop skills with our tutorials? That's what we do.

›› Change the blend mode to "Overlay" and keep the choke on 0%. Then increase the size to your desired level; we chose 90px because it gave enough depth to our sphere without being over the top. We then increased the range to make a softer inner glow and dropped the opacity down to 44%, so the inner glow doesn't drown the image [**Image D**]. Please note that every image will be different, so your project may require different levels. Create it to your taste; these are edits that we feel improve our particular image and aren't cookie-cutter figures, just guidelines.

7 FINISHING TOUCHES

Finally, we want to add a shadow to the sphere to finish off this tutorial. This will add a more physical presence to the sphere in the image. Simply make a new layer, then add one large circle of black using the brush tool. Press Ctrl-T to transform this, then squash and stretch the shape to create a shadow effect under the sphere. Change the blend mode to "Linear burn." Then reduce the fill, allowing the colors to interact more naturally with the background. Hooray! By now you should have a visually striking surreal art piece. We said it once, so we will say it again: Move over, Picasso. Hopefully, you will be able to transfer this technique into other projects and create some unique art and design following this guide.

Build a Better Liquid-Cooled Setup

YOU'LL NEED THIS

A SYSTEM TO BUILD
Plus water-cooling parts, bending kit, hand tools, imagination, and perseverance.

WATER COOLING A PC can be a daunting task for those new to the scene, and at times, even for some seasoned professionals, but where do you start if you want to take your build to the next level? Running a custom water cooling solution does bring a number of benefits, extending the life of the hardware, being able to have a virtually silent system, allowing for higher overclocks, stable temperatures, and much more.

Now, builds usually fall into one of two use cases: those that purely focus on productivity, and enthusiast or gaming setups. Both situations are, of course, first and foremost, dictated by the hardware to be used, and the performance required for each scenario. Productivity builds can obviously take advantage of the benefits that water cooling can bring, but in most cases, aesthetics are not a factor in the decision-making process. Enthusiast or gaming systems are a different beast, though—people want to show off their systems, it's part of the PC gaming journey. We are not talking about an AIO being slapped in a case; no, we are talking hard lines, pumps, reservoirs, and much, much more.

Here, we're covering some of the little things you should know, what to look out for when building a water-cooled system, and the options available before embarking on an adventure into the world of PC hydration. –KRIS BUTTERILL

A

1 PREPARATION

The most important step in any build, let alone a water cooling project. Plan, research, and measure.... Then do it again.

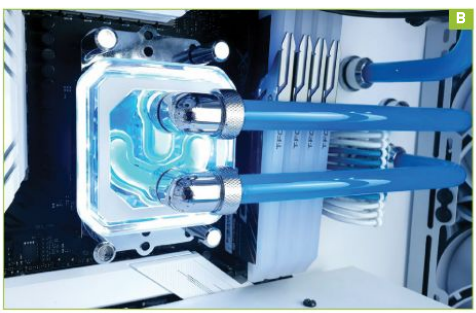
›› Decide on the key components for your use case first, and build around that—this is the priority and dictates everything else. At this stage, don't think about the water cooling side too much, just bear it in mind and ensure that whatever case, CPU, motherboard, and graphics card you will be using are suitable and compatible for water cooling. Your case choice will have a massive impact on what can be supported—an ITX case for a full custom loop is going to be challenging, to say the least. Give yourself some room to maneuver, especially for a first attempt. Consider the case airflow, mounting options for radiators, pumps, and reservoirs. You might end up going back over and revising the case choice, for example, but if you end up revising hardware to fit the cooling, then it's time to rethink. Cooling is there to support the hardware, not the other way around.

2 PLANNING

Once you decide on the hardware, it's time to decide on the cooling specification. Are the water cooling parts you have in mind adequate and suitable for what you need? It's no good running a 10900K and an RTX 3090 on a single 120mm radiator. The rule of thumb is to have at least one 120mm or 140mm section per component, plus an additional section, so at least a 360mm/420mm radiator for a simple solution. Loop order can be debated all day long, but for most scenarios, it's not hugely important. Provided that the pump is located with a gravity-fed supply of coolant to prevent it from running dry, don't worry about it too much. Preferably, this will come from a reservoir, but it can be from a radiator or even a block.

›› Will the system run in series, parallel, or even a dual loop? Series loops are the most common; just make sure that it's planned using the "In" and "Out" ports for CPU, GPU, and pumps. Parallel loops are less common; but can be used if space is a little tight, or you want a different look, while dual loops separate the CPU and GPU—however, it means at least two pumps, reservoirs, radiators, sets of fans, and power connections, making them more complicated than needed, unless aesthetics are the goal. Parallel runs offer a more minimalist option [Image A].

›› Drawing the loop on a piece of paper can really help visualize the layout and flow direction—think


B

about access to fill and drain the system, and placement of the components. It's also time to think about what type of tubing you want to use: soft or hard. If this is your first go, our advice is to go for soft tubing. This makes it easier to put together, but will help build your confidence before attempting custom-bent hard line. It's also not too difficult to convert to hard line, too—the only thing to change out are the actual fittings, and it can be done later down the road.

›› Finally, do you have everything you need, in terms of equipment and tools? A bending kit is great for hard-line runs, a sharp blade for soft tubing, a heat gun, files, pipe cutters; they can all potentially add more cost to a build. For simple 90-degree hard-line runs, there are pre-bent options available from the likes of EKWB and Alphacool, with most manufacturers also offering complete bending kits, too.

3 PARTS

Water cooling isn't cheap—at a minimum, you are going to need a pump, reservoir or combo, radiator, CPU and/or GPU block, fittings, and pipe. Fittings soon add up, and so does the cost, so making sure you get the correct parts is essential. The most common type of thread is G1/4, with fittings available in a range of diameters—10mm/13mm being a popular option. Ensure that everything you add to your basket is in the same sizes to prevent disappointment. In terms of making your build look unique, if you planned it well and researched the available parts, there are some great options. Pass-through, or bulkhead fittings as they are known, are great if you want to hide something away—for example, a pump under a PSU basement shroud. They can also help to run connections out of sight for a minimalist look [**Image B**].

›› Forty-five-degree connectors, multiport blocks, extenders, double-angle connectors, hard-line fittings, soft-tubing fittings; there's a myriad of options, with thousands of combinations. Distro plates are also now becoming more common, especially with cases such as the Lian-Li 011 Dynamic being such a huge hit. When you are picking fittings and connectors, always expect to place a second order. Quite often, no matter how much you plan and measure, there will be that one connection that could do with another half-inch clearance, or bend.

4 TRIAL AND ERROR

Now the hard part is putting it all together. For hard-line systems especially, use one type of fitting and you end up having a complicated multi-bend run to the next component. Change out the fitting type, add an extender, or move the placement of the component slightly, and it becomes a simple run. Using multiple fittings to simplify a bend also helps make tubing runs easier [**Image C**]. This can be a long-winded process, especially if you don't have a load of parts lying around just to try, but it really is worth taking extra time here. Remember not to overtighten fittings, and remove the protective film from CPU blocks—it happens more often than you might think.

›› Our number one tip is to try to keep it simple—simple is clean, elegant, and visually pleasing. For hard-line bending, make those 45s and 90s tight; not 85, not 95, you want 90. Any more or any less, and the end result is a "well almost" scenario, and you don't want that. Also, aim to have at least an inch or two coming off a bend into a fitting—it makes the whole dynamic of the loop more interesting and not seem cut short. Bleeding a loop can be a long process, so be prepared to tip and angle the case to get the air moving around the loop. Microbubbles will persist and eventually work their way out; just keep an eye on things and top up as required.

FINDING INSPIRATION

Planning a new build is an exciting time. You know the sort of look you want, but can't nail it down. Well, whatever case and part combination you have, chances are there is already a system out there with a full custom loop installed. Search the web, find inspiration from a previously completed build, a theme, color combination, sports team, your favorite game. Take pictures of certain aspects you want to incorporate from other builds you have seen, sketch ideas, play with fun reservoir placements—it all leads to something new and different.

Maybe take it one step further: Paint the case, etch the glass, add custom cables, a sleeper build, a desk build, the possibilities are only limited by your own creativity. Make the build your own, make it stand out from the crowd, and enjoy it—not just using it, but the journey of building it, too!

SERVICING—BEFORE AND AFTER

Every new system needs the components flushed before use, especially radiators, due to debris left over from the manufacturing process, which can clog up a whole loop, leading to problems down the line. Pressure testing before filling the loop is also a wise idea; unless you are super-confident, but we wouldn't advise skipping this either, because a leaky system won't last long.

Coolant choice is subjective; however, make sure you pick something that is designed for long-term use. There are some great color options, but beware that some are designed for only short-term use, such as exhibitions—these need flushing to remove all sediment from a system, and may stain reservoirs and blocks, too. Finally, stick a slot in your diary a year from now; an annual system flush, coolant change, and dust-off is essential for maintaining a healthy, happy system.

Machine of the Month: Fujitsu FM Towns (1989)

YOU'LL NEED THIS

TSUGARU EMULATOR AND BIOS FILES
http://ysflight.in.coocan.jp/FM/towns/Tsugaru/e.html

FANS OF OBSCURE GAMING are in for a treat this month, as we're going back to the Land of the Rising Sun to explore a different take on the PC, released only in Japan. If you've ever wanted to know what the PC would be like in an alternate reality, Fujitsu's FM Towns is the answer.

This "hyper media PC" provides a wealth of new experiences, ranging from desktop multimedia to brilliant arcade ports. So, join us as we explore a brief history of the FM Towns, and show you the easiest way to emulate it. –JOHN KNIGHT

1 BACKGROUND

The FM Towns was released as Fujitsu's response to the increasingly competitive Japanese computer scene, where machines such as the Sharp X68000 and NEC PC-8800 and PC-9800 series were dominating the Japanese market and eroding Fujitsu's sales.

›› While NEC's PC-9800 series had solid sales as 16 or 32-bit business desktops, its hardware was ill-suited to gaming and multimedia. Sharp's X68000 was a gaming powerhouse, but still only 16-bit.

›› Recognizing a gap in the market, Fujitsu's new machine would be a 32-bit multimedia powerhouse based on the Intel x86 platform. However, unlike the PC, this would be a proprietary platform based around specific chipsets.

2 LAUNCH

Shipping in February 1989, the FM Towns packed a 386 CPU, megabytes of RAM, and sound chips found in Sega consoles and arcades. Most notably, it was the first computer to ship with a CD-ROM drive as standard.

›› While its combination of chipsets already allowed for solid gaming, adding CD storage was transformative. Games could now be much bigger, and CD audio could provide proper studio soundtracks instead of MIDI. The added space also allowed for early FMV, with the FM Towns becoming famous not just for in-game cutscenes but also desktop multimedia.

›› Over the years, the Towns was given numerous generational upgrades. The oldest and slowest models had a 386 SX CPU @ 16MHz, while the newest and most powerful model had a Pentium @ 120MHz.

›› Hard drives were fairly rare; most software ran and booted from CD, like a '90s console, and floppy disks were used to save games. The Towns used a two-button joypad as standard, although more advanced controllers were available.

3 SOFTWARE

Numerous operating systems are available for the FM Towns, most notably Towns OS, a graphical environment that feels something like a cross between Amiga Workbench and GEOS. Otherwise, Japanese-modified versions of DOS, Windows 3.x, and Windows 95 are available for the system, and there have also been Linux and BSD distributions. Unlike the PC, operating systems for the Towns generally booted from CD.

›› Gaming-wise, the Towns has a mix of everything—usually with a Japanese twist. Arcade ports, small desktop games, manga adventures—there's something for everyone. Ports of famous Western DOS games were popular, often with enhanced soundtracks and extra content. Lengthy video cutscenes were common. To pick some highlights, arcade classics such as *Street Fighter II* and *Raiden* are well known (and both are solid ports), but connoisseurs should try *Asuka 120% Excellent* and *Viewpoint*. The Towns has arguably the best version of *Wing Commander,* and *Pu-Li-Ru-La* is probably the strangest game you will ever experience.

4 LEGACY

Despite the Towns's technical sophistication, its high cost meant NEC's PC-98 retained its lead in Japan until the mid-'90s, leaving the Fujitsu in a fairly niche position. However, all these Japanese computers sank into obscurity after Windows 95 PCs took over the market worldwide.

›› In 1993, Fujitsu released the FM Towns Marty, a simplified console version of the FM Towns that was compatible with most games. The Marty was the world's first 32-bit console, launching a year before the Sega Saturn and Sony PlayStation. However, the Marty was unsuccessful and did not receive much support, even from its parent company.

›› The FM Towns was retired in 1997, having sold around 500,000 units.

5 EMULATION

For English speakers, the only real choice of emulator is Tsugaru, by Soji Yamakawa. It's open source and supports Windows, Linux, and Mac.

›› You need to bear in mind that Tsugaru is still a work in progress, and doesn't support every feature of the

›› Believe it or not, half the reason Soji wrote his emulator was simply to play *Wing Commander* with an analog joystick.

© ORIGIN SYSTEMS

›› **The FM Towns: The PC that isn't a PC, which should be experienced by any serious PC gamer.**

Towns, but it's still worth a try. At the time of writing there was no full-screen mode and joysticks weren't working for the Linux version, but these issues may have been fixed by the time you read this.

›› To get started, head to the Tsugaru website (http://ysflight.in.coocan.jp/FM/towns/Tsugaru/e.html), where two links are provided: a GitHub link for downloading Tsugaru itself, and the other for the compatibility ROM, which serves as the system's BIOS. Not every title works, but there is certainly enough compatibility to make it worth your time, and getting genuine ROM files to run is otherwise challenging.

›› For Tsugaru, click the latest "Auto Release" link. Zipped binaries are provided for Windows, Ubuntu, and macOS. Linux users who don't have an Ubuntu-based system can try compiling from source. Download the latest binary release and extract the ZIP file in a new folder. For the BIOS, just click the link and save the ZIP file. Extract the ZIP file somewhere you can find it later.

›› Windows users can start the program by opening "Tsugaru_GUI.exe." Linux users can either click "Tsugaru_GUI" or, if that doesn't work, open a terminal in the Tsugaru folder and enter:

```
$ ./Tsugaru_GUI
```

SPECIFICATIONS

FUJITSU FM TOWNS (1989)

CPU:	Intel 80386 DX @ 16MHz
RAM:	1MB, upgradable to 16MB, later 128MB
Graphics:	16.78 million colors @ 640x480
Sound:	Ricoh RF5c68 sound chip, eight-channel stereo (PCM) plus YM2612 sound chip, six-channel stereo (FM synth)
OS:	Towns OS, plus custom Japanese variants of DOS/V, Windows 3.1, and Windows 95
Storage:	CD-ROM (540MB), 2x 3.5-inch floppy drives, optional hard disk or 5.25-inch floppy
Released:	February 1989
Launch Price:	¥400,000 (approximately US$6,000 today)
Production:	1989–1997
Japanese Sales:	500,000

FINDING SOFTWARE

Normally, this section is difficult to compile, but not this time. Just go to Archive.org. There are a few other sources here and there, but Archive.org has the most extensive collection. There are even freeware compilations, which are well worth exploring, so that's software that we can legally recommend.

Search for "redump.fm.revival" and you'll be taken straight there.

As for language barriers, if you don't fancy guessing your way through a bunch of in-game Japanese text, try sticking to major arcade conversions and famous DOS ports.

6 USAGE

To get started, you have to point to your BIOS files, pick a software image file, choose a control scheme, then start Tsugaru's virtual machine.

›› To choose your BIOS, under the "Main" tab, click the "ROM dir:" button. Now select one of the files from your BIOS folder to choose that directory.

›› To choose your software title, click the "CD Image:" button and choose the file for your CD-ROM image. We're assuming the software you want to run is on CD, but if your software is on floppy, click "FD0:" and choose your floppy image.

›› Before you start the emulation, it's worth defining your controls. If you don't have a joystick installed, click the "GamePort" tab, and from the "Game Port 0:" drop-down menu, choose "Emulation by Keyboard (Arrow and ASZX)." Click "START" and, with any luck, your game should load.

›› If your controller's fire buttons work but you can't move anywhere in game, under the "GamePort" tab, for "Game Port 0:" try choosing "GamePad0 (Analog Axes as Direction)," which re-assigns movement to a controller's analog stick.

›› If games refuse to boot at all, it's probably due to the compatibility ROM, but before giving up, try disabling any joysticks, and setting "Game Port 0:" to "Mouse" or another combination of mouse and joystick. Also, some games require a boot disk floppy, so check your ROM source for a list of companion boot floppy images.

›› ***Viewpoint*** **(1993) is a fresh and innovative take on scrolling shooters and a personal favorite of ours.**

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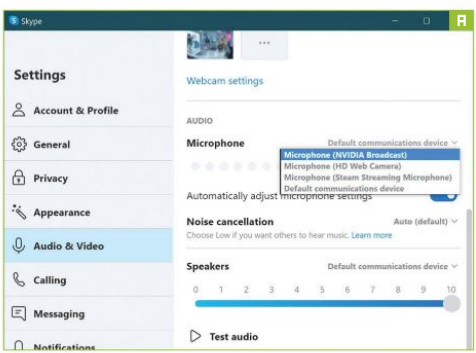
Improve Video Calls in Nvidia Broadcast

YOU'LL NEED THIS

ANY GEFORCE RTX GPU
With 8GB of DDR4, plus a Core i5-8600 or Ryzen 5 2600.

THAT EXPENSIVE GPU humming away in your rig isn't just for games or Folding@home work units—at least, not if it comes from Team Green. Nvidia Broadcast can also improve your calls and meetings by processing the audio and video streams to remove noise and echoes, or replace backgrounds, blur them, and even automatically crop the video to frame you more prominently.

The app used to be called RTX Voice, and if you're still using a GTX GPU, you can get hold of the old app, which will run happily on your card but doesn't do the camera stuff. Broadcast is RTX-only, however, so you need an RTX2060 or bigger/newer. According to the site, you also need 8GB of RAM and an i5-8600/R5 2600 or better. So, without further ado, let's look at how you can improve your calls with your graphics card. –IAN EVENDEN



1 INSTALL BROADCAST

Simple enough, this step. Go to www.nvidia.com/en-us/geforce/broadcasting/broadcast-app, download the file, double-click it. You know what to do.

2 ADJUST AUDIO

Make sure you've got your PC's microphone attached and working—you can delve into the settings to test it, or most voice apps allow you to make a test call, or at least see flickering level indicators that show your voice is being received. With Nvidia Broadcast running, you'll see it appear as a new input in the camera and microphone sections of your meeting app's settings. We've used Skype as an example [**Image A**]. Set it as your input, then return to Broadcast to fiddle with more settings.

3 MICROPHONE MUSINGS

The latest update to Nvidia Broadcast enables it to recognize and remove pet sounds from your audio. No, not the Beach Boys album, but any noise dogs and cats might make that interrupts you. It can remove the clicking of a keyboard, too, and the sound of cicadas. They don't make good pets, though. In the app's "Microphone" section, choose "Noise removal" from the drop-down menu under "Effects," and slide the switch to the right to activate it. Then click "Add Effect" to stack the other effect, which removes echo caused by the room you're in. There are sample audio tracks you can play to see the effect, but the best way to test them is to try them in a live call.

4 SPEAKER SILENCE

The same effects can be applied to incoming audio in "Speakers." It works the same way, so if the sound of someone's dog is echoing off the walls of their apartment, you can silence their misery here.

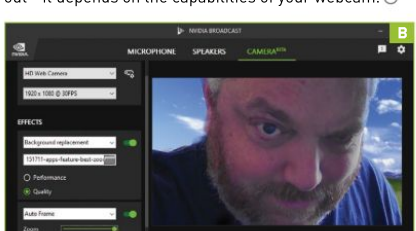
5 CAMERA TRICKS

It says it's beta, but the camera effects work well. We think background replacement might be a bit better than that available in meeting apps, too—but this can be difficult to measure, dependent as it is on the color of your hair, that of your background, and how much you wiggle around during a call. You can choose two effects from a selection of five. You can blur the background, replace it, remove it (leaving you floating in a black void), or remove video noise—useful if your lighting is insufficient. There's also Auto-Frame, which zooms the image in and follows you as you move, changing the area of the camera's sensor that's used rather than moving it. There's a slider to control the zoom, so it won't go too far and just show your nose [**Image B**]. The latest update lets you move a bit before Auto-Frame changes the framing.

›› Background replacement requires an image or a movie file, but sadly not an animated GIF. Background blur has a "Strength" slider, and lets you choose between "Quality" and "Performance" modes.

6 TWEAK SETTINGS

Clicking the cogwheel button opens a camera properties window from where you can tweak things such as the brightness and saturation of the feed. There's an "auto" option for each, but some are grayed out—it depends on the capabilities of your webcam.



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BUILD IT

ZAK STOREY, EDITOR-IN-CHIEF

A Pseudo Retro Conversion

The curious case of Raijintek...

LENGTH OF TIME: **1-2 HOURS** | LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

THIS IS A strange build for a number of reasons. We decided to do this because the case is really interesting. We were perusing various retailers on the hunt for a decent chassis to build in for this issue, and came across this sweet little ITX number: the Raijintek Pan Slim. It's an odd case style-wise, reminiscent of the early '90s PCs on which you'd stack a chunky CRT monitor. So, we set to task requesting one.

It took a while because we didn't have a direct relationship with Raijintek, despite having reviewed a few of its cases in the past (samples from Newegg), but after reaching out to the company, the PR got back to us, and we started to discuss the build. Usual questions were asked: "What will the coverage look like?" "What are you planning on building with it?" "How many readers do you have?" And so forth. Once we'd cleared all those checks and balances, we got to discussing the case itself.

Why is it so weird? Well, apart from its nostalgic throwback appearance, it's clearly listed everywhere as an ITX chassis. The PR, however, turned around and informed us that, with a reasonable dollop of elbow grease, it could be converted fairly easily to support ATX. Also, although the chassis doesn't technically support AIO liquid coolers (it does support two 120mm fans), again, with a little effort, you could make that a reality, too. And so, like a 200lb marlin, we were hooked, lined, and sinkered.

PARTS GALORE

THE QUESTION of "What chassis?" was answered, so the next problem was: "What the heck do we put in it?" And that's where things got a little complicated. The tech market, being the big mess it is right now, makes deciding what hardware to place in any build quite difficult, because there's not a lot of stock of anything anywhere. With the RTX 3080 Ti just having launched, it was certainly a contender, but it was immediately out of stock (Christian's hoping to line one up for a build next issue, though).

So, we decided to opt for something more "modest," if you can call it that. Instead of plumping for the latest-gen AMD chip, we grabbed a Ryzen 7 3700X eight-core. Instead of the latest flagship GPU chunking its way well into the four-figure area, we picked up one of Zotac's RTX 3060 Tis instead (at the not reasonable price of $610). And for everything else? We mixed it up with a combination of ADATA, Asus, Be Quiet!, and Corsair parts.

There is one stand-out part on that list, however, and that's the memory. We requested an ADATA kit (a recently launched budget-oriented product), but the ADATA team was out of review samples, so instead sent us a high-end 16GB kit of XPG Spectrix D50 memory, clocked at an impressive 4,133MT/s. Now, let's be clear, this motherboard hasn't been certified to run this particular memory at such high speeds, but we did get it working. It's rated for kits up to 4,800MHz and beyond (although we've no idea why you'd want to run memory at that speed on a B550 board). That said, as the kit is so cheap, it's worth the investment, and sort of future-proofs us against platform upgrades. Unless we end up on DDR5 in the next generation of chips and boards....

INGREDIENTS

PART		STREET PRICE
Processor	AMD Ryzen 7 3700X	$309
Graphics Card	Zotac GeForce RTX 3060 Ti 8GB Twin Edge OC	$610
Memory	16GB (2x 8GB) ADATA XPG Spectrix D50 DDR4 @ 4,133MT/s	$130
Storage	1TB ADATA XPG Spectrix S40G RGB M.2 PCIe 3.0 SSD	$160
Motherboard	Asus ROG Strix B550-F Gaming (Wi-Fi)	$200
PSU	Corsair SF 750W 80+ Platinum	$185
CPU Cooler	Be Quiet! Silent Loop 2 240	$140
Chassis	Raijintek Pan Slim Silver	$250
Total		$1,984

1 FUNCTIONAL FUNK

THERE AIN'T NOTHING we like more at *Maximum PC* than a funky-looking case, something that challenges the norm—not just another big black rectangular box—and the Raijintek Pan Slim provides that in spades. It's expensive, for sure, at $250, but it also packs one heck of an interesting design, with oodles of ventilation, bucketloads of style, plenty of premium materials, and arguably a fairly decent I/O, too (if only our mobo had an internal USB Type C header).

2 WHAT YOU GET

REMOVING THE PAN SLIM'S LID is not an entirely obvious procedure. There are four tiny Phillips screws, two on either side of the chassis, that need removing and then placing carefully to the side. With those out of the way, you can carefully lift the case's top off. It's a sheet of brushed steel, so be careful not to damage or accidentally warp it. It should retain its shape well (steel often does), but it's still not worth the risk. Once inside, you can see the interior layout. You've got your ITX location, a 3.5-inch drive cage, support for SFX power supplies, space for a three-slot graphics card in a vertical configuration, and even what appears to be a pump mount. Raijintek also includes a PCIe riser cable with the chassis, so no worries there.

3 OPEN CHASSIS SURGERY

WE'D LOVE TO TELL YOU that we spent hours converting this chassis to be able to allow it to take a full-sized ATX motherboard, using hacksaws, Dremels, and 15 yards of custom 3D-printed PETG, but that would be a lie. You know what we did? Removed that 3.5-inch hard drive cage, taking about three minutes to do so. Yep, that's it. That's how difficult it is to convert this chassis to take an ATX motherboard. There's a few extra considerations you have to take into account once this is done—most notably with the GPU installation—but you're pretty much there in less time than it takes to make a cup of coffee.

4 RGB NO SHOW

THERE'S A COUPLE of things we want to point out here. One that we forgot to mention prior to the installation of the motherboard is the Be Quiet! backplate—we can safely say that this is far easier to install with an AMD chip, compared to the Pure Loop 2 we detailed in the VR build a few issues back. Take off the AMD brackets, leave the backplate in place, install your spacers and bracket, then screw down, and repeat on the other side. Done. As for the XPG SSD? Well, that's something of a mixed bag. Technically, this thing shines real bright, thanks to some smooth RGB LED goodness, but, as you'll see in the next few steps, that might be more of an issue than you'd think.

7 MAGIC TIME

TIME FOR SOME MAGIC. We removed the two PCIe slot covers closest to the top of the chassis, then installed the PCIe riser into the top slot of the motherboard, making sure to carefully place and fold it so that the riser doesn't come into contact with the fans or anything else mechanical. Then we installed the GPU with the fans facing down toward the motherboard, and once that was secured, popped the riser card on the bottom of the GPU. Now, if that PCIe section were reversible, as we suggested earlier, we could easily have fitted this card in with the fans facing upward—no problem. There's even ventilation right above this in the chassis.

8 BOTTOM PANEL REMOVAL

ON TO THE FUN part: removing the case's bottom panel. To mod in our 240mm AIO, we need to secure it from the bottom half of the chassis. Only problem is, there's another chunk of brushed steel between us and all the necessary mounting locations. That said, again, removing the bottom is easy. Flip the case over and, similar to the top, you'll see the bottom panel is attached by tiny Phillips screws—but instead of four, there are 14 of the pesky pins. Remove every screw you can find from both the sides and the bottom, place them in the screw-organizer Raijintek includes, then carefully lift up the bottom housing, legs and all. Now you can install your AIO without a problem. Secure it in place using the screws that come with the radiator.

5 NON-REVERSIBLE?

THERE'S ONE MINOR TWEAK we'd love Raijintek to include in the next iteration of this chassis, and that's for these PCIe slots to be reversible. A simple cutout with two screws would do the job. Reason being, if you do decide to tinker with the thing and throw an ATX board in here, when installing your graphics card the fans will inevitably face the PCB. Now, yes, technically the chassis isn't rated for handling ATX boards, but this slight tweak (and a few extra mobo stand-offs) would make it a super-easy modification. In our case, we're lucky, because our RTX 3060 Ti is only a two-slot card (cooler and all), so we've still got plenty of space between the card and the motherboard to allow air to pass through and cool the card, but even so, that mobo PCB will heat up a touch, even with the PCIe riser in the way.

6 RISER WIZARDRY

AS WE KNOW, the GPU is going to be a bit of a pain once installed, and the PCIe riser is going to have to be folded in some special magic way to get it to sit properly and connect to the underside of the card, so it's best to get all the cables plugged in now for the front I/O or anything that needs to connect to the bottom side of the motherboard. The Pan Slim doesn't actually have a front audio header, so no worries there, and the front I/O headers are actually fairly thin on the ground, too—there's power, plus power LEDs, a USB Type C, USB 3.1 Type A, and that's it really. As the board doesn't sport a USB Type C header, we can pass on that and wrap it up later—just plumb the power cables in correctly, and we're done here, too.

9 FAN INSTALLATION

HERE YOU CAN SEE our first look at installing the fans in the Pan Slim. It's actually quite a tight case to build within, despite it being surprisingly roomy. The twin rad fits in here quite nicely, and has certainly got us thinking about over-the-top builds (a CPU with a 120mm AIO, or a hybrid GPU with a 120mm AIO attached might fit the bill). We've secured these fans down using just two screws on the diagonal, to give us an idea of how things are going to look. And then it's just a matter of installing the CPU block on the processor itself: Simply apply some thermal paste, remove the protective sticker on the bottom of the cooler, then secure it down using the pre-attached CPU block screws.

10 MEMORY IS EVERYTHING

WITH THE CPU BLOCK INSTALLED, it's now a matter of routing a few cables around, installing the pump's fan cable, and then installing the memory. Adding RAM to a build is a piece of ccake, although you do always need to take care that your memory kit is compatible when putting a build together (this seems to be more troublesome with AMD processors than with Intel variants). Aside from that, it's also worth noting that although this Be Quiet! cooler does indeed come with an aRGB header, if you don't install it, the pump will still shine a pure white. Handy if you don't like messing around trying to plug aRGB cables in everywhere.

11 ANNOYING I/O

THIS IS WHAT WE DON'T GET: This is a $200 B550 motherboard, yet somehow we can't have a USB Type C internal header on the motherboard, but we can have a port on the back of the I/O. Why? Seriously, why? Asus, explain it to me like I'm 12. Outside of that, the B550 is a pretty solid all-arounder. You've got a decent audio solution, Gigabit Ethernet, Wi-Fi 6 AX, seven USB 3.1 Type A ports, that annoying USB C port we mentioned earlier, DisplayPort, and HDMI out.

12 CABLING PROBLEMS

HERE'S PERHAPS the biggest problem with this case that we can see: the power supply requirements. It only supports SFX PSUs. And that means the majority of the time you're left with very short cables. Aftermarket power supplies, such as the Corsair SF series unit we're using here, have short cables by design, to help better accommodate smaller chassis. Problem with that is that they don't reach the 24-pin power or CPU power, because they're too short. To get around this, we've had to cannibalize a set of cables from one of the RMx series power supplies we had lying around the photo studio, as they fit and operate correctly in our SF variant, and thankfully reach. This isn't a motherboard thing, either, as even with an ITX board the cables don't quite reach.

13 SOLUTIONS?

HERE'S THE THING, THOUGH: This case is so large that you could easily fit an ATX power supply in the top as well. Again, similar to the ITX versus ATX argument, the Raijintek Pan Slim could easily support an ATX mobo, a two- or even three-slot card, and a full-size power supply, and still retain its super-slim look, if some small adjustments were made to the overall tooling of the chassis. Don't get us wrong, it's a fantastic case, it just needs some slight tweaks to make it more compatible with a wider array of devices. And if that were so, you could end up with a whole myriad of different builds in this thing. From funky monitor-stand-esque PC desktops, to ITX home theaters, to living-room gaming PCs, to little work machines for a small-scale office, to fancy liquid-cooled endeavors.

14 BUILD COMPLETE

AND THERE YOU HAVE IT! One completed, funky-looking ITX (sort of ATX) system build that you can place under your monitor. It's a modern and stylish take on a classic design, and it's an incredible amount of fun to build inside. There is room for improvements, of course, as there always is with any product, but nonetheless, we highly recommend the Pan Slim case if you're after something a little out of the ordinary. Also, Raijintek, if you're reading this, include some vertical stands and a way of removing those feet in the next iteration, please—then we can get to grips with some even crazier builds in this absolutely unique case.

1. **A bigger power supply cutout here for an ATX PSU would be a lovely addition.**

2. **Cable management is a bit of a problem, but there's no window, so you can't see inside.**

3. **If only we could flip this GPU so its fans were facing upward....**

4. **These fans should really face the other way, exhausting heat up and out of the chassis to match convection.**

CONCLUDING THOUGHTS

AND THAT'S IT. A super-slick, clean build in a very nice Raijintek case. What was the process like? Honestly, it was incredibly refreshing. Building in the Pan Slim was a breeze. There wasn't any worry about tilting it on its back or on its side. Literally place the case on a table, take the top off, and you can start work immediately. It makes the whole job exceedingly easy.

There were a few things we forgot to mention in walkthrough, so we'll include those now. Firstly, there are the three support struts that run across the top. These are removable via the Phillips screws located top and bottom. We took out the middle one to give us enough access to install the ATX motherboard, and the one on the far right to allow us to better fit the AIO liquid cooler. They also perform double duty as handy cable tidy areas. Simply gather up all your loose cables and use a cable tie to secure them to one of the struts.

Another thing to be wary of is the motherboard stand-offs. You'll need to buy a few extra, and drill or secure them to the case in the correct positions. We've got the board mounted on just the four ITX ones currently, and although that's technically OK, and there's no actual weight on the board and it's not hanging anywhere, it's not something we'd recommend.

All in all, though, it's a lovely chassis, available in black, white, or silver, and a genuine piece of curiosity, in our opinion. And as for our build's performance? That's quite impressive, too. Although the GeForce RTX 3060 Ti is way overpriced right now, and Nvidia goofed the non-crypto-mining driver, if it ever does make it to retail prices, at 1440p ultra you're looking at frame rates well above the 100 mark on average across most titles. That's not too shabby. In fact, at 4K it creeps past the 65fps mark. It even outperforms some of our older RTX 2080 Super builds. Neat, huh? We'll leave the chart below to do the real talking, but it's potent, that's for sure. Heck, even comparing it to the RTX 2080 Super on that inflated price point, it's not bad value for money either.

The ultimate question is, should you build a rig like this? If you're a fan of the case, and are after something a little different, then absolutely. And these specific components? Well, it's not a bad setup for a gaming PC either, if you can get the parts. Just be wary of your power supply cables, and if you do want a chunky GPU, sticking with an ITX board might be a better option, at least until Raijintek releases an updated SKU with our requested changes.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,398	2,185 (56%)
CrystalDisk QD32 Sequential Read (MB/s)	3,531	3,522 (0%)
CrystalDisk QD32 Sequential Write (MB/s)	3,473	2,988 (-14%)
Middle Earth: Shadow of War (fps)	78	52 (-33%)
Total War: Warhammer II (fps)	75	48 (-36%)
Shadow of the Tomb Raider (fps)	85	53 (-38%)
Red Dead Redemption II (fps)	78	47 (-40%)
Assassin's Creed Valhalla (fps)	54	38 (-30%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i5-10600K, 16GB DDR4 @ 3600, an MSI GeForce RTX 3080 10GB SUPRIM X, and a 1TB Samsung 980 Pro (operating at PCIe 3.0). All tests were performed at 4K on the highest graphical profile available.

LAB NOTES

ZAK STOREY, EDITOR-IN-CHIEF

Will We Ever Get Total Ray Tracing?

The math says no

I'VE BEEN HAVING fun with ray tracing in *World of Warcraft* and *Cyberpunk 2077*. It's pretty cool, but it's not perfect—most importantly, in what it tries to mimic: light.

A quick tl;dr on ray tracing. Nvidia has dedicated hardware on its current-gen RTX cards that simulates how light works by using "rays" to predict certain variables. It does this by bouncing an individual particle or ray off the geometries and materials in the game scene to try to get a better understanding of how shadows are formed and light reacts with those materials. That gives more realistic shadows, reflections, and refractions. It's the same technique used in a lot of CGI in Hollywood blockbusters. The difference is that in GPUs we only use a comparably small number of rays per scene, as it takes an incredible amount of processing power to achieve this in real time, so a lot of the gaps are plugged with clever use of both traditional rasterization and ray tracing.

Nvidia doesn't state how many rays its 3000 series cards can produce per second, but we can extrapolate figures from the 2000 series. The RTX 2080 is capable of eight gigarays per second, or eight billion rays, and 25 RT TFLOPS. The RTX 3080 more than doubles that TFLOP figure to 58, so we can assume that's an increase of 132 percent performance purely on ray tracing. So, the 3080 should produce around 18.56 gigarays per second at peak operation.

The thing is, this isn't enough to replicate life as we witness it ourselves. Firstly, light doesn't behave how rays do. Rays try to mimic a proton as a particle, on a pixel by pixel level, whereas light is both a particle and a wave, depending on how and if it's observed, with multiple photons bouncing off in all directions. And the number of rays is infinitesimally small in comparison. That's not to say what we have is a bad solution or it doesn't work well, just that if we want truly photorealistic games, we're still a very long way from where we need to be, and it's likely to remain that way long into the future with our current computing solutions, methodologies, and materials.

Ray tracing is impressive, yet flawed.

ZAK STOREY

Editor-in-Chief

I'd like to dedicate this issue to my late grandmother, Janet Storey. Sadly, she passed away on June 14 after a very long, arduous battle with acute myeloid leukemia. I fortunately got to see her two days before she passed to say goodbye. She was a fantastic woman, incredibly strong willed, infinitely curious, loud, and particularly nosey. All traits that she passed down to me, and which I attribute as being contributing factors to ending up where I am today. I wouldn't be who I am without her, and I wouldn't have gotten to spend as much time as I did with her in those final weeks without the computers and tech our industry is such a big part of.

CHRISTIAN GUYTON

Staff Writer

Oh boy, those GPU shortages don't feel like they're going away anytime soon. My fiancé's graphics card has been acting up, so I went for an online trawl to see if an upgrade was feasible. Turns out, not really. I'm not willing to pay above RRP for a two-year-old GPU to begin with, but $900 for an RTX 2060 is laughable. The problem persists beyond the PC market, too, with birthdays across the globe being ruined by PS5 shortages. As developers push the envelope with progressively better graphics, a worrying disconnect is emerging. What's the point in a game being beautiful if 80 percent of the audience can't find or afford the gear to play it?

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Editor's Pick:
Elgato EpocCam App and Multi Mount L

Where the iPhone meets webcam

SINCE OWNING my first laptop at the age of 11 (an Acer netbook), I have never needed to purchase a webcam. Luckily for me, the Acer netbook and every computer I've owned since have all had webcams built in, and they were more than sufficient when using those devices, as I have never been one to use a webcam frequently. Sure, Skype was great for speaking to my friends and family, but I didn't really care for the toaster quality they were seeing. And now, at work when I am in Google meetings or on Zoom calls to loved ones or the *Maximum PC* team, quality is important. You want to see people in the best quality, not a grainy, pixelated image. Sure, if your Internet is bad, there is no fix other than to upgrade that, but an upgraded webcam would give everyone a clearer image of my ugly mug.

This is where Elgato comes in. Its product is super-easy to set up and use. I tested the Multi Mount system and EpocCam app for iPhone, and you can read my full review on pg. 88. The app essentially turns your iPhone into a webcam—seems too good to be true, right? Well, no, it works well, and I'll get on to that in a second. As for the mounts, I was more than satisfied with the build quality; exactly what I would expect for a desk mount. Installation was easy, and the height of it easily gets over my 34-inch ultrawide monitor when it's clamped on to the desk. Meanwhile, the phone grip has more than enough clearance for my iPhone XS and holds it very securely above my monitor.

I've been using the "essential" mount, appropriately named the Master Mount L. This is the main stand that clamps on to a desk or table. It easily fits on to my cheap Ikea desk with no problems, and it won't cause any damage as it is nicely padded. Due to its strong build quality, it doesn't wobble either.

All the parts connect together with ball joints that are simple to add and work universally with other accessories, too. The connection is super-secure, so you never feel like it will collapse or your phone will drop. I tested the Flex Arm L, too, which is another set of poles to create all sorts of camera angles. It's probably best used for a top-down approach, and if I were more of a content creator (and talented), I would definitely use it for top-down tutorial videos.

As for the app, using it is a breeze. I tested the free version, but I recommend getting the paid-for pro edition. As good as the free app is for turning your phone into a webcam, it doesn't film in FullHD. Elgato has used its brain here and thought of something that now seems pretty obvious: most people have a very capable smartphone with an HD camera, so why not use that camera so you don't have to get a high-quality webcam?

Setup is very quick, although I did have to install a driver and iTunes back on my PC. You can connect through USB, but I prefer connecting wirelessly; just make sure both your PC and phone are connected to the same network.

If you need a webcam, it's a great route to a reliable HD cam. Just opt for the $7.99 pro app—it's still going to be cheaper than a separate webcam. The mounts will bump that price up, but are well worth the outlay. The only downside? No support for Android just yet. **–SL**

EpocCam App: Free/$7.99
Mount parts from around $25
www.elgato.com

Reviewed...

76 Nvidia GeForce RTX 3080 Ti

78 Acer Predator Orion 3000

80 Asus ROG Zephyrus G15 GA503Q

82 HP E27D G4

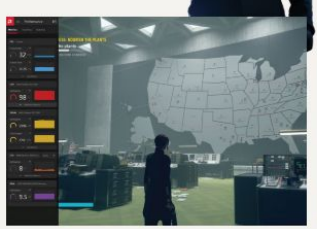
84 Cooler Master MasterBox 540

87 Razer Opus

88 Elgato EpocCam & Multi Mounts

89 SteelSeries Rival 5

90 Resident Evil Village



92 AMD Radeon Software vs. Nvidia GeForce Experience

Nvidia GeForce RTX 3080 Ti

Say hello to diminishing returns

IT'S TIME ONCE more for the mid-cycle upgrades. After last year's big reveal of the Ampere architecture and its higher performance, Nvidia is back to fill in the gaps. Add some additional cores, bump clock speeds a bit, and toss in some extra memory and the associated memory bandwidth. Et voila, we have the RTX 3080 Ti, filling the small gap between the RTX 3090 and RTX 3080. Nvidia pitches this as the "ultimate Ti" and makes reference to the still excellent GTX 1080 Ti, but it fails to live up to those lofty expectations.

On paper, the 3080 Ti looks a lot like the 3090, just with half the VRAM and two fewer SMs (Streaming Multiprocessors). Considering most games don't need anything like 24GB of memory, which is more useful for professional workloads, we expect the 3080 Ti to land closer to the 3090 than the 3080. And it does.

Across our test suite, the RTX 3080 Ti comes in just a few percent behind the RTX 3090. In practice, no one will notice the difference. However, it's a similarly small jump compared to the RTX 3080. The 3080 Ti beats the 3080 by about 12 percent at 4K but only 8 percent at 1440p, and just 5 percent at 1080p. Temperatures are also higher, thanks to the increase in TDP, and the Founders Edition cooler struggles a bit to keep up, particularly on the GDDR6X, where temperatures of 100–104 C are common.

The 3080 Ti ends up landing between the proverbial rocky 3090 and hardy 3080, but with a price closer to the 3090. According to Nvidia, the 3080 Ti has an MSRP of $1,200, versus $1,500 for the 3090 and $700 for the 3080. Of the three, the RTX 3080 is by far the best value. The 3080 Ti nominally costs 71 percent more for about 10 percent more performance, a classic case of diminishing returns.

MINE SHAFT

Not that it matters much in today's market. The great GPU and component shortage rages on, and every moderately fast graphics card has been out of stock and overpriced since last fall. The pandemic deservedly gets much of the blame, but cryptocurrency mining of Ethereum in particular has made a bad situation worse.

To that end, the RTX 3080 Ti implements an improved version of Nvidia's hashrate limiter that cuts Ethereum mining performance basically in half—we measured 57MH/s. Nvidia also updated the other 30-series cards (except for the RTX 3090) with limited hashrate models that replace the earlier versions. Will that be enough to curb demand from miners, and will Nvidia manage to keep mining performance locked down this time? Time will tell on the latter, but demand for the 3080 Ti looks just as bad as the other Ampere cards, with prices of around $2,500 on eBay.

If you want a graphics card for professional work or even cryptocurrency mining, you're better off grabbing the RTX 3090—assuming you can find one in stock at an acceptable price. For pure gaming, the 3080 Ti succeeds in delivering near-3090 performance for less money. It's also generally faster than AMD's RX 6900 XT, particularly in ray-tracing games or if you enable DLSS, but it costs more and AMD's FidelityFX Super Resolution (see "Tech Talk," pg. 13) may have something to say about upscaling performance.

The RTX 3080 Ti ultimately ends up following in the footsteps of the RTX 2080 Ti rather than the GTX 1080 Ti. It carries the same Titan-level price, but it showed up late to the party, and the not-quite-a-Titan RTX 3090 already fills that role. It's not a bad card, but it definitely feels like a money grab from Nvidia. Even worse, we're already seeing third-party cards with prices in the $1,600–$1,800 range. Unfortunately, it looks as though we'll be seeing inflated GPU prices throughout the rest of 2021. –JARRED WALTON

BENCHMARKS

	Nvidia GeForce RTX 3080 Ti FE	Nvidia GeForce RTX 3090 FE	Nvidia GeForce RTX 3080 FE
Eight Game Average	108/72	**112/74**	99/64
Assassin's Creed Valhalla (DX12 1440p/4K)	86/59	**90/60**	77/52
Borderlands 3 (DX12 1440p/4K)	126/74	**128/76**	111/65
Control (DXR 1080p/1440p)	104/69	**109/71**	97/63
Cyberpunk 2077 (DXR 1080p/1440p)	69/46	**71/48**	64/42
Dirt 5 (DX12 1440p/4K)	141/98	**149/100**	124/85
Horizon Zero Dawn (DX12 1440p/4K)	130/88	**137/94**	130/79
Metro Exodus (DX12 1440p/4K)	113/75	**115/77**	102/67
Red Dead Redemption 2 (Vulkan 1440p/4K)	114/80	**117/83**	104/72

Best scores are in bold. All testing conducted with a Core i9-9900K, MSI MEG Z390 ACE, 2x 16GB DDR4-3200 CL16, 2TB XPG 8200 Pro M.2 SSD, Seasonic Focus G 850W. Scores are average frame rates at indicated resolutions.

VERDICT **7**

Nvidia GeForce RTX 3080 Ti

+ HOME RUN Excellent performance on a proven architecture.

– RERUN Inflated price; insufficient supply; power-hungry.

$1,200, www.nvidia.com

SPECIFICATIONS

Architecture	GA102
Lithography	Samsung 8N
Boost Clock	1,695MHz
GPU Cores	10,240
Memory	12GB GDDR6X 19Gb/s
TFLOPS FP32	34.1
Bandwidth	912GB/s
TDP	350W
Connectors	1x HDMI 2.1, 3x DisplayPort 1.4

The RTX 3080 Ti FE's added memory chips, cores, and clocks might be too much for the cooler.

Air is drawn in through the front and top, then vented through the rear.

Acer Predator Orion 3000

A small but mighty system

CONSIDERING THAT, on paper, it's a pre-built gaming powerhouse, the Orion 3000 is surprisingly compact. Its case has a capacity of just 18 liters, and the whole rig weighs under 22 pounds. With a footprint less than 15 x 7 inches, it can squeeze comfortably on or below any desk.

It's a fairly unassuming PC, all things considered. Its relatively small size and gentle RGB front lighting don't immediately grab your attention the way bigger, badder machines do. The $1,500 price tag isn't particularly demanding, either, especially as it contains a GeForce RTX 3070, which is extremely hard to find right now. The prospect of scooping up a powerful pre-built system instead of trying to out-bid bots in the GPU scalping war is certainly attractive.

If it wasn't a giveaway, the RTX 3070 is matched with a similarly impressive bevy of internal components. An octa-core i7-10700 handles core processing, supported by 16GB of HyperX Fury RAM, while storage is covered by a 512GB M.2 SSD and a 1TB hard drive. It's all neatly packed away, with cables routed along the front, sewing together the proprietary motherboard and power supply.

Said power supply provides 500W of power, almost half of which is immediately guzzled up by the GPU. It isn't a problem, and there's a bit of headroom for overclocking, but it could prove to be an obstacle to future piecemeal upgrades. Such upgrades are otherwise a definite possibility, as the guts of this system are tidy enough that swapping out most components for new ones should be a cinch. There's also an empty bay for an additional SATA drive, should you wish to add one.

The Orion 3000 has seen many iterations in the past, and this is one of the more costly models. Cheaper variants sporting graphics cards such as the RTX 2060 and GTX 1660 mean that this still (just about) falls within the purview of an "affordable" gaming desktop. As such, there are a few aspects of the Orion 3000 that feel a little on the cheap side.

PLASTIC RAP

For starters, the front I/O is hidden behind a flimsy plastic door, above which lies a pop-out headphone rest that wobbles alarmingly to the touch. While you can swap out the metal side panel for an included tempered glass window, the transparent front panel appears to just be acrylic plastic.

The case fans are a bit on the weak side, with only two dinky 100mm fans, one in the front and one to the rear. Most galling is the use of a stock Intel cooler for the CPU; while this could easily be swapped out for a better air cooler, there's nowhere to install a radiator for an AIO cooler, which is a shame. That said, this machine didn't struggle thermally during system stress tests.

Connectivity is simple and sweet, with rear video and audio outs joined by seven USB-A ports and a lone USB-C. The lack of optical audio out will be felt by some, but this has everything the average gamer needs. Wi-Fi 6, "Killer" Ethernet, and Bluetooth 5 sweeten the deal.

In terms of performance, the Orion 3000 matched our expectations for a good RTX 3070 system. 4K gaming is an option, but you have to be prepared to drop the graphical settings a little if you want to maintain over 60fps in most triple-A games. 1440p is the sweet spot, offering stable, high frame rates at max settings in most games. 1080p sees frame rates soar above 100—ideal for anyone rocking a high refresh rate monitor.

General rendering tasks are a breeze, with the GPU and CPU proving their worth. One area where the Orion 3000 failed to impress was its SSD transfer speeds; although this system uses PCIe 3.0, which should be capable of read speeds approaching 3.5GB/s, the Western Digital M.2 drive here was barely able to reach 2.5GB/s. Will this make a noticeable difference? Probably not, unless you transfer huge files around on the regular.

Overall, this is hard to fault. The asking price is a tad higher than we'd expect to pay if we were building it ourselves, but that's part of the pre-built deal; a higher cost, but less hassle. Plus, this is a sure-fire way to get an RTX 3070 GPU, given the current bot-storm purchasers face when trying to buy one alone. If you're on the lookout for a solid new gaming desktop, the Orion 3000 won't steer you wrong. **–CHRISTIAN GUYTON**

VERDICT **8**

Acer Predator Orion 3000

+ CONSTELLATION Great 1440p performance; good value for money; compact chassis.

– DARK SPACE Front of case feels cheap; only 500W PSU; stock cooler is meh.

$1,500, http://acer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	2,408 (11%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	2,477 (-21%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	1,812 (-15%)
3DMark: Fire Strike Ultra (Index)	6,988	8,506 (22%)
Total War: Warhammer II (fps)	42	60 (43%)
Tom Clancy's The Division 2 (fps)	38	50 (32%)
Metro Exodus (fps)	37	56 (51%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i9-7900X, 32GB G.Skill RipJaws V series DDR4 @ 3,000MHz, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile. *Metro Exodus* tested at 4K at High.

SPECIFICATIONS

CPU	Intel Core i7-10700
Graphics	Nvidia GeForce RTX 3070 8GB
RAM	16GB DDR4 HyperX Fury @ 2,666MHz
Motherboard	Predator Orion 3000
Primary Storage	512GB WD SN530 M.2 PCIe SSD
Additional Storage	1TB 7,200rpm HDD
Cooling Solution	Intel stock
PSU	500W
Case	Predator Orion 3000
Warranty	One year

Asus ROG Zephyrus G15 GA503Q

With a GPU rarer than diamonds, does the G15 shine as bright?

IT'S ALWAYS EXCITING to get a lot of power in a relatively small form factor, and the laptop we have been blessed with for this review happens to fit into this category, with the much-coveted GeForce RTX 3080 inside. Partnered with an AMD Ryzen 9 5900HS, it should surely pack a punch; and it does on paper, at least.

Asus's Republic of Gamers division has been releasing impressive gaming tech since 2006, and the hardware on offer is only getting more exciting. So, the Zephyrus G15 has a lot backing it, but does it perform adequately? Well, it's certainly no underdog.

As a 15-inch model, it's the average laptop size, but that's the last time we will use "average" in this review. With the lid closed, this machine looks sharp. On the top, it has a diagonal perforated design that shimmers iridescently in the sunlight, replacing the LED matrix found on the Zephyrus G14. In the corner, it even bears a small silver plaque with the ROG logo, name, and establishment date—very classy. Once opened, the keyboard offers deep key travel and feels great to type with. The keys are white, which ties in with the overall design, and are backlit in white light—no RGB here. The trackpad is also white and great to use; it's very large and responsive, so does exactly what it should.

Moving upward, the screen, like everything else we've mentioned, does not disappoint. The QHD 15.6-inch display is very rich in detail and color. Everything is crisp, with a refresh rate of 165Hz. If we had to make a criticism, it could be a bit brighter, but you can't have it all. The thin bezels around the sides and top make it appear larger than other laptop screens, which can be swamped by chunky surrounds. Unfortunately, this also means there's no webcam. Considering the price tag, this is a disappointing omission. To complement the great screen, though, you also get a great audio experience. Laptop speakers aren't renowned for their quality, but the G15 manages to pump out decent sound for everyday media consumption.

It's not all looks, though; this machine has the brainpower, too. The AMD Ryzen 9 5900HS is an excellent chip that handles everything without a sweat, with the compact RTX 3080 just as able to hack away at any task you throw at it. What more could you want from a laptop's performance? Gaming is bliss, everything running at a high FPS very comfortably. With that high refresh rate and vibrant display, games look gorgeous. The Zephyrus G15's 32GB of RAM feels like overkill but is happily welcomed. A 1TB SSD is equally good to see, giving you ample storage for games. As for ports, the G15 is packed out pretty well with two USB-C and two USB-A ports, Ethernet, HDMI, 3.5mm jack, and a microSD slot.

For a gaming laptop, this goes above and beyond. With some of the best internals you can get right now, the spec sheet could do all the talking here. At $2,499, it is undeniably expensive, and at that price its plastic chassis does feel a little cheaper in the hands than other machines, especially the recently reviewed Razerbook 13, which boasts an excellent premium build quality. However, the Zephyrus G15 is a stunning, super-powerful package. Just a shame that you can make a Zoom call on a Chromebook but not on this. **–SAM LEWIS**

VERDICT **9**

Asus ROG Zephyrus G15 GA503Q

WOW, WOW, AND WOW Electric performance; snappy QHD display; stunning design.

ALMOST THERE GUYS No webcam; expensive; not the best build quality we've seen.

$2,499, www.asus.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	2,137 (107%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	3,595 (7%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	3,107 (23%)
3DMark: Fire Strike (Index)	13,610	20,529 (51%)
Rise of the Tomb Raider (fps)	92	107 (16%)
Total War: Warhammer II (fps)	62	83 (34%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	61 (24%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	AMD Ryzen 9 5900HS @ 3.30GHz
Graphics	Radeon Graphics, Nvidia GeForce RTX 3080 GDDR6 8GB
RAM	32GB DDR4 3,200MHz
Screen	15.6-inch QHD @ 165Hz
Storage	1TB SSD
Ports	1x HDMI 2.0, 2x USB 3.2 Gen2 Type-A, 2x USB 3.2 Gen2 Type-C with Power Delivery and DisplayPort, 1x 3.5mm combo audio jack, 1x microSD card reader, 1x RJ45 LAN port.
Connectivity	Wi-Fi 6 (802.11ax), Bluetooth 5.1 (dual-band)
Weight	4.2lb
Size	0.8 x 9.6 x 14.0 inches

Clean, striking, and powerful; anything else you need?

HP E27D G4

1440p productivity at a painfully premium price

HOW MUCH ARE you willing to fork out for features like USB-C connectivity, monitor daisy-chaining, Ethernet connectivity, and a webcam with facial recognition? A hundred bucks over an otherwise identical monitor? Two hundred? More?

Enter the HP E27D G4, a 27-inch productivity monitor with a 1440p IPS panel. It has all that stuff and plenty more. But it will cost you around $220 extra compared to HP's entry-level 27-inch IPS 1440p offering, the 27MQ. Ouch.

Still, along with the fat feature set, this panel also packs slick industrial design, with crisp styling, slim bezels on three sides, and great build quality. The specifics of the broader feature set are impressive, too.

The USB Type-C interface supports 100W of device charging, which is as good as it currently gets, plus daisy-chaining a second monitor, and forwarding of both a four-port USB 3.1 hub and an RJ-45 Ethernet port. In other words, you can connect a laptop to the E27D G4 via a single cable, drive the display itself, charge the laptop, and connect to peripherals and networking. Nice.

It's a modern version of laptop docking that doesn't depend on proprietary hardware and is compatible with any laptop with USB-C functionality. For the record, the monitor daisy-chaining is enabled by both USB-C and DisplayPort-out sockets, ensuring support for a range of panels, not just another E27D G4.

Rounding out the main attractions are a pop-up webcam with IR facial recognition and Windows Hello support, plus a fully adjustable stand with rotation into portrait mode. The HP E27D G4 supports audio pass-through and a soundbar is available separately, but as standard it does not have integrated speakers.

If that all sounds pretty comprehensive, what this monitor doesn't deliver is high-end image fidelity. The 2560x1440 native resolution is decent in a general productivity context, but it's well short of the full 3840x2160 4K grid you might expect at this price point.

HP makes similarly modest claims for the color accuracy of the E27D G4. It says it's good for 99 percent of the sRGB gamut but doesn't quote performance for more demanding spaces, such as Adobe RGB and DCI-P3. Long story short, this monitor is neither suitable for nor pitched at serious content creation workflows including image and video editing.

Nor is it capable of HDR rendering. Rated at 300 nits and 1,000:1 contrast, the HP E27D G4 is an unapologetically SDR panel. Expectations suitably calibrated, however, the image quality is actually pretty pleasing. Speaking of calibration, HP has done a good job of just that, with natural, vibrant colors and little to no compression in white or black tones.

What's more, the E27D G4 looks punchier than the 300 nit spec, while the viewing angles are as good as you'd hope from an IPS monitor. OK, there's a little IPS glow and the pixel response doesn't set new standards, but HP includes user-configurable overdrive in the OSD menu.

While we're talking OSD features, it's worth noting the absence of presets for popular color spaces such as Adobe RGB and DCI-P3. Not even sRGB is on the list. In a more general sense, also not included is the precision associated with 4K. The 1440p resolution isn't poor, but it's down on detail and sharpness compared to 4K. Likewise, fonts aren't as crisp.

Overall, the HP E27D G4 makes for a practical productivity workhorse by most metrics. But for this kind of money, we'd prefer 4K to 1440p. **–JEREMY LAIRD**

VERDICT **8**

HP E27D G4

PREMIUM PRODUCTION Comprehensive connectivity feature set; slick build quality.

BUDGET CUTS Limited color coverage; 1440p rather than 4K native resolution.

$524, http://hp.com

SPECIFICATIONS

Panel Size	27-inch
Panel Type	IPS
Resolution	2560x1440
Brightness	300cd/m²
Contrast	1,000:1
Pixel Response	5ms
Color Coverage	99% sRGB
Refresh Rate	60Hz
VESA	100 x 100mm
Inputs	DisplayPort 1.2, HDMI 1.4, USB-C with 100W charging

HP's panel combines 1440p resolution with plenty of productivity features.

It might have a tempered glass window, but the MasterBox 540 needs more fresh air.

Cooler Master MasterBox 540

Striking design, but at a cost

COOLER MASTER is no stranger to the case market, offering an extensive line-up to suit every scenario and budget. The Cooler Master MasterBox 540 adds yet another product to the MasterBox series, the company's website now listing a total of 64—yes, 64—MasterBox options.

The MasterBox 540 is marketed as "Gaming in a New Light," a reference to the aRGB backlit front panel that takes its inspiration from automotive lighting. Given its experience in the case market, Cooler Master seems to have taken something of a gamble here and pinned its hopes on people liking the front panel backlit design. It's either a really risky or a really clever decision on Cooler Master's part, and it's refreshing to see a manufacturer not being scared of trying something new.

Overall, the MasterBox 540 is undeniably a fabulous-looking case, and it's nice to have a tempered glass side panel that isn't clad with thumbscrews, keeping the aesthetic nice and clean. It's toolless, too, with an optional rear-mounted thumbscrew included for a more permanent fixing solution. The front panel is made of plastic, though; it's glossy, as well, meaning that scratches will stand out, so some care is going to have to be taken during installs and maintenance. Above the gloss trim is the front I/O; it's not a vast suite, but most certainly useable, including a USB Type C port. A good mobo choice will reinforce the connectivity—let's face it, most front panels are used for a controller, thumb drive, and that's about it.

Being a mid-tower case, radiator support is sometimes compromised; however, the MasterBox 540 steps up and can handle up to a 360mm radiator to both the top and front of the case. Fitting radiators is also a breeze, Cooler Master implementing a removable top panel to make installations so much easier. It's a roomy case, with full loop support, plenty of storage mounting options for those large game libraries, a vented PSU shroud, and dust filters to the bottom, front, and top, with the top one being magnetic. Longer power supplies can be accommodated by removing part of the hard drive sled mount cage under the PSU shroud, and Cooler Master also includes an aRGB controller and three-way splitter, making lighting up a build really simple. Nice touch, Cooler Master.

The MasterBox 540 only ships with a single 120mm aRGB fan to the rear, though, and that, sadly, is where this case starts to fall down. Cooling performance is massively hampered by the plastic front panel, with only a limited amount of ventilation space for the case to actually suck air in to breathe. Removing the front panel is an easy job and improves the efficiency of the case massively. Perhaps, as we have seen before with Cooler Master, the MasterBox 540 might get a revision—a mesh version, perhaps. Sure, it would remove some of the aesthetic marketing that this case relies on, but it would offer so much more to the user. It's not like Cooler Master hasn't done this before either, is it?

The price of the MasterBox 540 is also a concern; there are plenty of other, better case options available for the same change. It's a shame, because at a lower price point, despite its limitations, this would be a viable option. We can forgive the inclusion of only a single fan on a case that offers potential, at $60–$80 maybe. At that price, it would be a more interesting chassis, given all the positives it offers—and there are plenty of them.

Listing so many models in the MasterBox line-up strikes us as alarming; perhaps Cooler Master would be better taking a quality over quantity approach. There are many other case manufacturers out there that prove this is achievable. It's frustrating, and maybe it's time for Cooler Master to rethink its overwhelming line-up -KRIS BUTTERILL

VERDICT **7**

Cooler Master MasterBox 540

MASTER Great radiator, aRGB, and storage support.

DISASTER Poor airflow; simply priced too high for what it offers.

$150, www.coolermaster.com

SPECIFICATIONS

Motherboard Support	E-ATX, ATX, mATX, Mini-ITX
2.5/3.5-inch Drive Support	4x/2x or 6x 2.5
Max Radiator Support (mm)	Top: 360; Front: 360; Rear: 120
Fan Support (mm)	Top: 3x 120/2x 140 Front: 3x 120/2x 140 Rear: 1x 120
Dimensions (L x W x H)	19.5 x 8.1 x 19.5 inches
Graphics Card Clearance	16.1 inches
CPU Cooler Clearance	6.5 inches

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Razer Opus

Can Razer enter a new market?

IT'S ALWAYS interesting to see a company switch into a new line of products. The transition can be a scary move for a team with a fixed brand identity, but Razer seems to be handling this new expedition into a more lifestyle-oriented sector of the tech world pretty darn well.

That's not to say it has abandoned its gaming ethos by any means, but with more productivity-focused devices coming out, it's really pushing the brand forward. One of these products is the new Opus headset, a slightly different set of headphones from Razer's traditional gaming cans. So, how does the Opus perform, and can it stand up to other music/media-focused headphones?

As a pair of active noise-canceling (ANC) Bluetooth headphones, they certainly differentiate themselves from other Razer headsets. The Opus has ditched the green accent color associated with Razer's gaming division and replaced it with clean silver detailing. The headphones are very sleek and have a minimal black design. Razer's logo has also been switched out for text-only branding that sits on both sides of the headband, while the left cup features nothing other than a tiny THX logo on its face. All the ports and buttons are located on the right-hand side, including USB-C for charging, 3.5mm jack, mic, power button, light indicator, volume up and down buttons, and a button that needs to be held down for five seconds to activate "gaming mode." That's right, Razer had to feature some sort of gaming angle, and hats off to the company for doing so, as it's always going to be a big part of the brand. As for battery life, you can get around 25 hours with ANC enabled, which is pretty solid. We'll talk about ANC more later on.

At first glance, it certainly looks as though the Opus could creep into the higher end of the headset market, but what is it like to wear? Well, the lightweight nature of the cans makes them fade away on top of your head, perfect for listening to music and relaxing. We mentioned that the headphones are sleek, but the cups are still deep, with plenty of soft cushioning and not too much clamping force. They certainly don't challenge the comfort of some more high-end headphones, such as the Sony WH-1000XM4, but that's not to say they aren't comfy. You can get plenty of listening time in without these headphones bothering you. The build quality is solid; the main construction is plastic, with metal bands in the headband, and this combo makes for a lightweight headset.

As for the most important part of a pair of headphones, the sound quality, it's pretty dang good. Razer has been making better and better audio peripherals as time goes on. With a step away from gaming, the Opus produces a rich but balanced sound. Its detail is clear, though not the clearest we have experienced. However, this is complemented by a deep bass that doesn't overwhelm the overall sound. Nice work, Razer.

The cans are THX certified for high-fidelity sound, and this is borne out in practice. This, paired with the great ANC feature, makes for a good-quality package. Talking of active noise cancelation, it's always a great feature to have and works very well. Blocking out background noise makes for a much more immersive listening experience; we all know the hustle and bustle of everyday life can sometimes get a bit much, so it's great to zone that out with a slice of ANC.

As a whole, Razer has demonstrated that it can venture into more of a lifestyle peripheral market with the Opus, a good-looking, good-sounding pair of headphones that offer impressive active noise cancelation. They are decent in all areas, but this might be a slight downfall, because there are no specific areas in which the headphones excel. On the flip side, they are a very well-balanced set and more than capable of delivering a great sound and look. The bottom line is that Razer has proved that it can produce a good-sounding headset away from the gaming market. Audiophile headphones next, perhaps? –SAM LEWIS

VERDICT **8**

Razer Opus

MAGNUM OPUS Clear rich audio; lightweight build; immersive ANC.

MAGNUM PI Trebles are a little weak; microphone quality is lacking; expect more premium materials for the price.

$200, www.razer.com

SPECIFICATIONS

Driver Type	40mm dynamic driver
Frequency Response	20Hz-20,000Hz
Impedance	12 ohms
Connectivity	3.5mm jack, Bluetooth
Design Style	Closed back

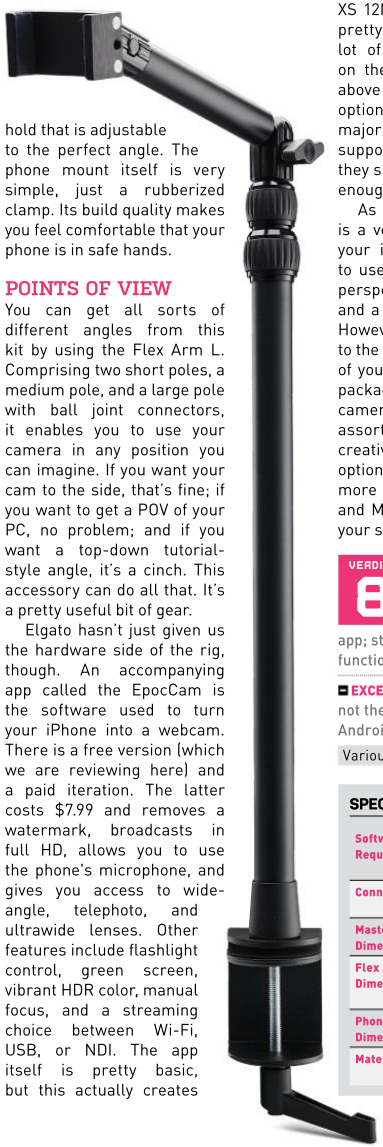
Elgato EpocCam & Multi Mounts

Repurpose what you have

WE ALL KNOW HOW important it is to have a webcam, especially in a pandemic. Staying in touch with loved ones, friends, and work colleagues is essential for keeping the world ticking. As crucial as webcams are, though, nobody wants a PlayStation 2 EyeToy-quality conference call, so upgrading our webcam is a choice a lot of us have made. Elgato, however, has provided an alternate method. It clearly looked in its pocket and thought: Hey, phones have pretty good cameras; they'd make pretty good webcams, right? And so we have the Elgato EpocCam app, with an accompanying assortment of mounts to turn your iPhone into a webcam. Sounds like a reasonable alternative and it makes the most out of what you already have. This could be a great use of an old phone that would otherwise just be collecting more dust than an Xbox 360.

Tripods, mounts, and stands suffocate the market. There are millions of variations at all sorts of prices, all of which do different things. What Elgato is offering here is a variety of solutions to use your iPhone as a webcam. The company calls this modular rigging system the Multi Mount. In the combo set we've got a Master Mount L, Flex Arm L, and a Phone Grip, which do exactly what you'd expect. All of these products are extremely well put together and made out of durable materials, with only the fastener being made of plastic and the poles from forged steel. With this comes great reassurance that your phone will not move in the mount. Nobody likes a wobbly webcam, do they?

The main part, the Master Mount L, is what attaches to your desk/table. The bottom section has a screwable foam padded clamp, which is strong enough to ensure a sturdy foundation for the rest of the rig. In theory, for a basic webcam mount, all you need is this. It extends to 49 inches, although it's recommended that you extend it to around 35 inches for the best rigidity. All the accessories connect with ball joints that fasten together; one is included that you can also use for any typical camera. The sturdy ball joints create a very strong hold that is adjustable to the perfect angle. The phone mount itself is very simple, just a rubberized clamp. Its build quality makes you feel comfortable that your phone is in safe hands.



POINTS OF VIEW

You can get all sorts of different angles from this kit by using the Flex Arm L. Comprising two short poles, a medium pole, and a large pole with ball joint connectors, it enables you to use your camera in any position you can imagine. If you want your cam to the side, that's fine; if you want to get a POV of your PC, no problem; and if you want a top-down tutorial-style angle, it's a cinch. This accessory can do all that. It's a pretty useful bit of gear.

Elgato hasn't just given us the hardware side of the rig, though. An accompanying app called the EpocCam is the software used to turn your iPhone into a webcam. There is a free version (which we are reviewing here) and a paid iteration. The latter costs $7.99 and removes a watermark, broadcasts in full HD, allows you to use the phone's microphone, and gives you access to wide-angle, telephoto, and ultrawide lenses. Other features include flashlight control, green screen, vibrant HDR color, manual focus, and a streaming choice between Wi-Fi, USB, or NDI. The app itself is pretty basic, but this actually creates fewer complications; after all, it's just a webcam. Connecting it is easy enough—just follow the onscreen instructions, download the correct software on your PC, and change the input on your desired software. It's just as easy to connect through Wi-Fi as it is through USB. All good then, eh?

The thing is, the webcam can only be as good as your phone. Tested on an iPhone XS 12MP camera, the footage came out pretty good and smooth, challenging a lot of pre-existing webcams available on the market. It requires iOS 13 and above to work, though, so no it's not an option for Android users. Thankfully, the majority of iPhones, especially ones that support iOS 13, have decent cameras, so they should all make for more than good enough webcams.

As an all-in-one package, the app is a very easy solution for repurposing your iPhone. You can flip the camera to use both front and back, change the perspective, apply a background blur and a green screen, all in the free app. However, we do recommend upgrading to the paid app to unlock the full potential of your iPhone. The mounts secure this package and make for a pretty awesome camera setup that you can use for an assortment of reasons. If you are a creative or just looking for an alternate option to a traditional webcam that offers more features, the Elgato EpocCam and Multi Mount are a great addition to your setup. –SAM LEWIS

VERDICT **8**

Elgato EpocCam & Multi Mounts

➕ **REPURPOSING** Easy, effective app; strong, sturdy construction; wireless functionality; multipurpose.

➖ **EXCESSIVE** Expensive as a package; not the most elegant-looking setup; no Android support.

Various prices from $25, www.elgato.com

SPECIFICATIONS

Software Requirements	iOS 13 and above, Windows 10 or later, macOS 10.14 or later
Connectivity:	Lightning USB connector, Wi-Fi, NDI
Master Mount L Dimensions	Max height 49 inches
Flex Arm L Dimensions	Long pole 9.45 inches, medium pole 6.7 inches, short poles (x2) 3.15 inches
Phone Grip Dimensions	Max width 3.35 inches
Materials	Steel, hard composite, tough rubber

SteelSeries Rival 5

Jack of all trades, master of none

IT ISN'T ANY SECRET that we really do enjoy using SteelSeries products. Its hardware often checks all the relevant boxes, and it's very rare that the company launches a complete dud, so when we saw the Rival 5, we had to grab one.

The Rival 5 is marketed as being inspired by a chameleon for being able to meet the needs of many, and being versatile as it does so, but how well does it hit the mark?

The shape of the mouse is pretty solid—it is similar to the Logitech G900 but with a less bulbous rear, making it fit comfortably in your hand, especially with a palm or claw grip. Eight out of the nine programmable buttons are easily accessible, even with smaller hands; however, the large silver sniper-style thumb button is quite far forward, and those without large hands will struggle to reach it.

The paddle takes some getting accustomed to, as well, but once you've used it for a few days, it's quite intuitive. We used it for voice comms more than anything; paddle up for TeamSpeak and down for Discord. Great if you use different comms while gaming. The sensor is fantastic, too, and didn't skip a beat during our testing. It tracked decently, had an impressive lift-off distance, and didn't stutter or struggle with any of our usual surfaces. To our knowledge, the sensor is based on the PixArt PAW3335, a low-power sensor, usually reserved for wireless mice. It's capable enough, and would only be outdone by something like a PMW3389 or similar. It's certainly more than enough for a mouse at this price point. The switches feel fine; they're not the best of the best, but unless you've tried hundreds of mice, you wouldn't notice.

For those who like light mice, the Rival 5 comes in at just under 3oz, so not really a contender when comparing it to ultra-light mice. It's also not heavy enough for those who like a bit of heft to their mouse, either. It isn't an uncomfortable weight, though, and we actually like where it sits on the scales. The cable has a nice tight weave and slips well on surfaces, so it's fairly unobtrusive, almost as good as wireless.

BUTTON BANTER

The design ideology for this mouse is that it can be used in pretty much any type of game, regardless of the genre. Put to the test, in FPS games the Rival 5 did very well—it was nice to use and comfortable. In a MOBA, all the buttons you need are there, but we found them far less intuitive than some other MOBA-specialized mice. For MMOs, we found ourselves simply lacking buttons. Really, the paddle was the only feature we used constantly, and that wasn't dependent on the game—we kept using it for comms, because it was just far more efficient than trying to use it for something in-game.

SteelSeries Engine is one of the better software suites, and with it you can change the CPI, key bindings, and lighting, and also set macros. You can also set the mouse to change keybindings automatically, depending on the game you load, which, for a mouse marketed toward variety gamers, is a big bonus.

All in all, the Rival 5 isn't a bad mouse by any stretch. It is comfortable to use, the sensor is fantastic, and its lighting is vivid, unique, and interesting compared to many other mice. However, by trying to be a jack of all trades, it misses the mark in most genres. It comes across as more like a generalist mouse, rather than a specialist one. And rather than it being like a chameleon showing its versatility, you might prefer it to adopt that reptile's disappearing trait instead, and just grab a mouse that is more suited to your specific needs. –DAVE ALCOCK

VERDICT **7**

SteelSeries Rival 5

CHAMELE-CAN Great sensor; comfortable to use; excellent in FPS games; fantastic lighting options.

CHAMELE-CAN'T Thumb button very far forward; not great in MMO or MOBA-style games.

$60, www.steelseries.com

SPECIFICATIONS

Sensor Model	SteelSeries TrueMove Air
Max Sensitivity	16,000 cpi
IPS	400
Acceleration	40G
Programmable Buttons	9
Connection Standard	USB 2.0, 6.7 feet
Battery Life	N/A
Weight	0.19lb

It's tempting to stand and watch her ladyship move around, but also fatal.

SURVIVAL HORROR GAME

Resident Evil Village

Not the towering achievement its early levels suggest

YOU HAVE BEEN LIED TO. In trailers, early showings, and generally all press materials, *Resident Evil 8* was shown to be a game about a tall vampire lady who pursued you through a crumbling mansion. And it's really kinda not.

There is a tall vampire lady, of course, and she's one of the best things about the game, but her presence takes up barely 25 percent of its runtime—she's effectively the tutorial. The section involving her is also over too early, frontloaded in a plot that also involves her daughters, four other boss characters, werewolves, faked deaths, parasites, bio-organic weapons, Chris Redfield, the kidnapping of a baby, and that strange crossover between religious cults and the biological sciences.

A direct sequel of *Resident Evil VII*, *Village* does something it thinks is clever with a Roman numeral but mainly just recycles the main character, Ethan Winters. Otherwise it feels like a completely different game. Each new *Resi* game since *Resi 4* has redrawn the boundary between horror and action, and *Village* is no exception. There is indeed a village, acting as a hub between what you might call levels, or possibly "adventures." And while the presence of the village brings out some distinctly *Resident Evil 4* vibes, this game attempts to tip the balance slightly further toward the horror side, bringing in familiar tropes such as the European vampire family, a dreadfully sinister talking doll, and the werewolves (sorry, lycans) that make up the bulk of the things you'll kill.

Winters himself is still a blank slate—he even appears in the game's promotional art with his face obscured—and as the game takes place in first-person, he's mainly a pair of hands. These appendages, when not squeezing off precise shots to conserve ammo or tremblingly reloading, take a lot of damage. Such a lot, in fact—bitten through by werewolves, pierced by hooks, sliced open (then severed completely) by vampires, only to be reattached, and more besides—that the game has to retcon his existence all the way back to *Resi VII* (in which his hand was severed and stapled back on).

Winters's extreme powers of regeneration are matched only by his utter dullness. Compared to the characters he's up against, he's nothing. Even the merchant who supplies him with extra guns is more interesting. An LA systems engineer, he's an attempt to root the series in something more believable than a special forces soldier who never skips leg day, but something about playing as him just doesn't work. Whether it's his vulnerability in the face of being able to staple his arms back on, or the tedious lines he utters when confronting exploding biological horrors, the player frequently ends up more panicked than the protagonist. He is on a quest to save his baby daughter, however, which must focus the mind somewhat.

And the fact that his quest takes him first to Castle Dimitrescu seems like a misstep. The first two sections are the best the game has to offer, and this frontloading of quality is all the more noticeable in a game that's really not that long. Lady Dimitrescu, all nine feet of her in stylish hat and strangely clingy dress, pursues you through her castle with the help of her daughters, forcing some high-speed thinking and stressful

© CAPCOM

The RE in RE Engine doesn't stand for *Resident Evil*, but Reach for the Moon, somehow.

Lycans. Why did it have to be lycans?

Definitely not a baddie in disguise. No way.

It's a suitably Gothic Eastern European setting.

puzzle-solving. It's great fun, with simple brain-teasers involving lighting braziers and shifting statues around as much as shooting things in the face. These puzzles are less intricate and just plain easier than in previous *Resi* games, but the whole area is improved enormously by the presence of Lady D. As an update to Mr. X, she's extremely effective, although the fights with her daughters rely too much on the same mechanic—getting them cold, which slows them down.

EYE-CATCHING ENVIRONS

Her ladyship does, however, exemplify one of the "traditional" *Resident Evil* conceits that we wish they'd give up on. She's bulletproof, and her demise depends on you finding a single item. There's plenty more, too, including the save system that doesn't feel at home in a modern videogame, the section that removes all your weapons, and more bulletproof enemies that aren't telegraphed as such. There's some poor pathfinding later on, as well, although even in remote European villages, signposts saying "bad guys this way" must be rare. Once you've passed through the excruciatingly creepy second area, all porcelain dolls and eyes that glint in the darkness (if you've ever found TV ventriloquists scary, this is not the section for you), the following submerged village, ghoulish factory, and final boss fight are surprisingly gimmick-free—just unload everything you've got against the shifting mass of spiderlegs and ragged wings, before it can do the same to you.

Capcom's remarkable engine brings the body horror to jerking, biomechanical life, and it's almost worth turning the brightness up to get a better look at the awful things you're encouraged to see only lurching at you from the shadows or with the sights of your gun partially obscuring your view. This does rather diminish the menace and panic, however, so we couldn't possibly recommend it as a way to play the game. Beware, also, of the new pricing structure. Introduced with the latest generation of consoles, the price of triple-A titles is creeping up, making a launch purchase less of an impulse and more a considered decision.

And while its four-act structure and drop off in quality halfway through can make *Resident Evil Village* feel somewhat like a game in search of a single identity, in its favour it is an action/horror game with a lot of ideas, from the traditional to the modern, mashed together in its 12-hour runtime, and unlike its predecessor, it isn't too beholden to particular horror movies for its inspirations. Never less than interesting, and genuinely excellent in its early levels, this is a game of hunting monsters in which we are never invited to question who the real monster could be. There's little here we haven't seen before, but it's the way it's put together that makes you grimace. –IAN EVENDEN

VERDICT **7**

Resident Evil Village

GIANT VAMPIRE Excellent beginning; rampaging action; superb design.

LITTLE SUCKER Quality tails off; blocking move too difficult; possibly slightly absurd.

RECOMMENDED SPECS i7-8700 or R5 3600 CPU, 16GB RAM, GTX 1070 or RX 5700 GPU.

$80, www.residentevil.com/village, ESRB: M

The Radeon overlay gives you as much information as you want, thanks to expanding toolbars.

Radeon Software vs. GeForce Experience

Battle of the, uh, utility software

ON A FUNDAMENTAL level, Nvidia's GeForce Experience software and AMD's Radeon Software (also known as Adrenalin) are exactly the same. Both offer device driver management and capture utility alongside specialized support for a variety of games. The dividing line, of course, is that Radeon Software is designed for use with AMD GPUs, while GeForce Experience is the app you need if you're rocking an Nvidia card.

It's not that simple, naturally. GeForce Experience has been around for a wee bit longer than Radeon Software, at least in its current incarnation, and it's not unfair to say that AMD clearly copied Nvidia's homework whenever Experience added a new feature. Both consistently recommend that you upgrade to the latest and most expensive GPU, for example....

This sort of software started life as simple driver update tools, designed to remove the need to manually track down the right drivers for your component on the manufacturer's website. The premise was straightforward enough: The software identifies the relevant components active in the system, then locates and installs the appropriate drivers automatically.

Both pieces of software still do this, although installing new graphics drivers is hardly difficult. The program had to do more to become a selling point for AMD and Nvidia to push to consumers, so the rivals looked to the primary use of dedicated GPUs in desktop PCs and laptops: gaming.

Capture software has long been a tricky business for PC gamers, so Radeon Software and Experience can both capture and record game footage for livestreaming or video production, each using an overlay.

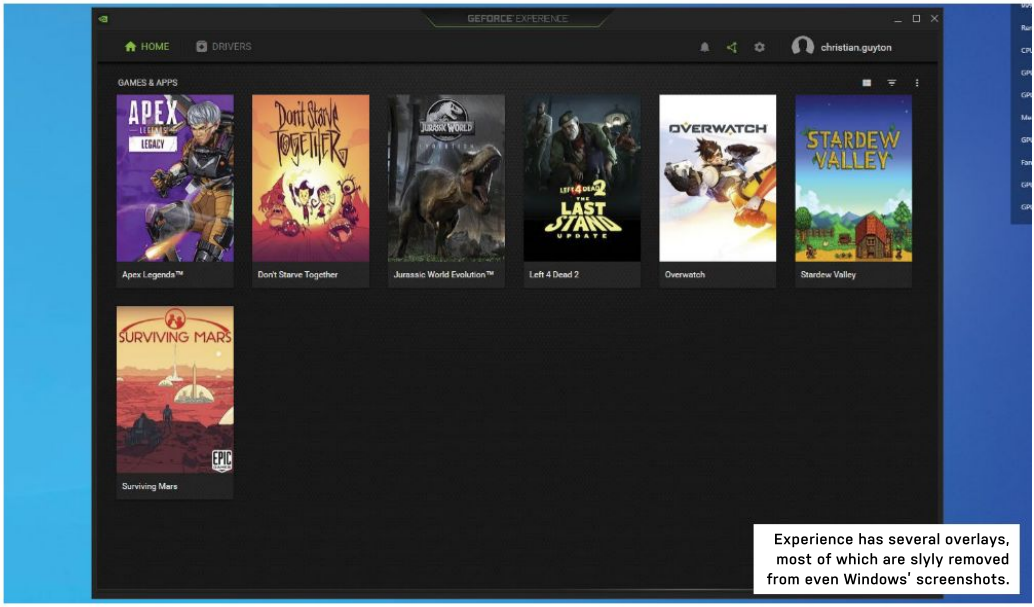
Essentially, the software constantly records, enabling you to snip and save a juicy play like a DVR instant replay. High-res screenshots and GIFs are also only a few clicks away with both programs—ideal for social media snapshots. GeForce Experience calls its capture toolkit ShadowPlay, and boasts up to 8K HDR recording. Radeon Software is more low-key, with just a "Record and Stream" tab.

GeForce Experience has a leg-up on AMD in this arena, and it's called Nvidia Ansel. This is essentially a souped-up photo mode for around 200 supported games, enabling you to take crisp ultra-res screenshots or 360-degree images that can later be rotated when viewed, or experienced in VR. Nvidia also hosts a "Shot with GeForce" gallery on its website, where users can upload their best pics.

There's something to be said for how smoothly Nvidia's capture overlay operates. The Radeon Software overlay is a bit clunky in comparison; while it offers almost all the same features, Experience feels easier to use. Grabbing footage is snappy, with easily rebindable hotkeys for specific tasks. Experience also allows you to add filters to Ansel-supported games in real time, changing the lighting or color correction to suit your preferences. Both perform well for game capturing, but Team Green offers a subtly superior experience.

Boosting game performance is another key area, with AMD potentially taking back some ground. GeForce Experience readily optimizes a game's graphical settings for you automatically, enabling any baked-in

© AMD



Experience has several overlays, most of which are slyly removed from even Windows' screenshots.

Nvidia hardware features such as DLSS and G-Sync. Radeon Software does this, too, but also hands you more control over which AMD-exclusive features to use.

There's plenty to choose from, too. Radeon Anti-Lag dynamically adjusts frame timing to minimize input lag, a vital inclusion for twitchy *Valorant* players. Radeon Chill alters your FPS in accordance with your GPU temperature, while the excellent Radeon Image Sharpening uses a contrast-adaptive algorithm to improve visual clarity with minimal performance impact. These settings have sub-settings, such as allowing you to set minimum and maximum FPS targets for Radeon Chill.

Sure, some of these boosts can be achieved on an Nvidia GPU without using GeForce Experience, but it's handy to have them all collated for easy use. Overall, Radeon Software feels better suited to the average gamer, but if you're trying to build a career and need capture software, GeForce Experience is the better choice.

What else can these programs do? Well, game-streaming is one increasingly popular feature, beaming gameplay live from your powerful gaming PC to different devices. Radeon Software has got you covered here; AMD Link is a free and easy-to-use app that connects to your PC and enables you to stream games directly to your device of choice, be that a laptop, phone, or smart TV. It's an excellent tool that can be used to play your favorite games remotely, although it does demand some excellent Wi-Fi on both ends.

GeForce Experience doesn't have the same clout when it comes to streaming to other devices. It does enable compatibility with the Nvidia Shield TV media player, enabling you to play PC games from your couch even if your PC is in another room, but this requires a Shield unit, and these start at $145. Nvidia did have a feature similar to AMD Link in the works—named Nvidia Gamestream—but that seems to have fallen by the wayside. Amusingly, AMD Link can be used on the Shield TV, reinforcing AMD's "any device" mantra.

The only other key feature is system monitoring, and there's only so much that can be said about that. Experience and Radeon Software both enable you to track stats like frame rates and temperatures on the fly, via an overlay or in the app proper.

Again, Experience offers a superior overlay here, with friendly sliders for adjusting specs such as voltage and fan speeds. Radeon Software has more detail in-app, which will please some users. If you want to know details such as your CPU's thermal current, AMD has got you covered. AMD's tool also includes a built-in web browser, but this feels superfluous.

Ultimately, you're beholden to the software that your GPU adheres to—or none at all, as neither is mandatory and there are plenty of alternatives; HWMonitor can handle component monitoring, while Windows 10's Game Bar is more than sufficient for quick and dirty game capture. These two pieces of software are both good at what they do and intuitive, and we'd probably give AMD a slight edge if we were forced to pick one winner, but the difference is small enough that it shouldn't be a deciding factor when it comes to choosing a new GPU. –CHRISTIAN GUYTON

VERDICT 8

AMD Radeon Software

RAD Super-detailed monitoring and tweaking; AMD Link is great; solid capture suite.

BAD Overlay is a little laggy; UI isn't as intuitive as Nvidia's.

RECOMMENDED SPECS Intel Pentium G/AMD FX or better; 2GB RAM; AMD Radeon HD 7700 or better; Windows 7/10

$Free, http://amd.com

VERDICT 8

Nvidia GeForce Experience

FORCEFUL Snappy overlay; great capture and editing tools; simple and readable UI.

FRAIL Monitoring isn't as detailed; Shield TV sucks a bit.

RECOMMENDED SPECS Intel Pentium G/AMD FX or better; 2GB RAM; Nvidia MX100 or better, Windows 7 or better.

$Free, http://nvidia.com

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Phone Problems
> Ultimate Audio
> More Gaming?

S21 Ultra Woes?

Dear Zak, In your June 2021 issue, vol. 26 no. 6, on page 73 you mention that you got a Samsung S21 Ultra. You gave it a thumbs-up.

But when I went to the website for Verizon, it gave it 2.5 stars out of 5. Now the reviews say after the April update most of the phones stopped working properly. And there were a lot of very bad reviews for that phone.

So, my questions to you are: Have you had any issues with your phone so far, and how would you rate your phone? I was planning to buy that exact phone until I saw those reviews. So, any info you can give me would be much appreciated. **–Ken P.**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Hi Ken, this is actually the first I've heard of any problems so far. I haven't had any personally; my last update was in May (it's June at the time of writing), and still no major issues or bug crashes, although I've spotted some comments online with all manner of problems, so there's clearly some issues somewhere.

I believe I've actually got an international model, rather than a country-specific one, with an Exynos processor (seems to be true according to CPU-Z; also, didn't know there was a CPU-Z for smartphones—it's really cool), as Samsung Pay won't register on it, because it states the phone isn't compatible for whatever reason. So, perhaps it's something to do with the Snapdragon processors conflicting with that particular software update, but not the international Exynos chips maybe. I imagine Samsung will be quick to patch that, remove the derailing update from its servers, and repair any damaged phones in the process.

Judging reviews is always something of a difficult task. On the one hand, you have tech journalists and reviewers like ourselves, who often don't have a long time with the device before they have to review it. So, certain bugs and long-term issues can be missed, which means sometimes it doesn't give you an accurate representation of what it's like to live with the product. On the other hand, reviews from members of the public, more often than not, pop up when someone's having issues or problems with the device, and they're looking for some support. So, you could see a score of 2.5 out of 5 from user reviews, equating to 50 percent of total reviews being negative; however, that could be less than 1 percent of the total S21 Ultra user base. It's very hard to tell. If something just works, and works well, it's rare for people to go out of their way and compliment it, I find. Angry voices often shout loudest. That's not to say that their opinions are invalid—and, of course, there are clearly problems with those devices—just that it's something to bear in mind when gauging a product's performance in both user reviews and journalist reviews.

Unfortunately, I can only provide anecdotal evidence myself really, which is less than helpful in this scenario. I'm still having a lot of fun with it, though. The cameras alone are incredible, and it's super-smooth and quick, too. I don't game on it, however, or do anything particularly system-intensive with it, and it's mostly sitting on a wireless Qi charging pad throughout the day.

One thing that I do regret is the cost. It's seriously expensive—more so than any phone I've had before; pushing the four-digit mark—so I'm really paranoid about dropping and damaging it. In fact, this is the first phone I've ever had where I have a case on it day in, day out, even when I'm not out exploring or mountain biking.

Audio for PCs

Hi Zak, Thanks for keeping the mag going. Love the "Blueprints" section now. I know you don't really review a lot of speaker systems, but is there anything you'd recommend? I was thinking of getting a soundbar because there don't seem to be any good 2.1 speaker systems around anymore really. **–Terry L**

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: This is actually quite an interesting question, admittedly a few months old now (sorry, Terry!), but I wanted to respond publicly once I got the relevant things in. You're right—we don't do a lot of audio testing. It's

↘ submit your questions to: editor@maximumpc.com

something we're sort of trying to expand our remit with a touch (but with a PC focus, of course; you're not about to see hi-fi units every issue).

I was in a similar position. I had a Razer Nommo Pro 2.1 setup back in 2019, but it died after about half a year or so, sadly, due to an internal electrical fault, I was told. So, I got rid of it, and grabbed a cheap Logitech MX Sound Premium Wireless setup (like a cheap version of the G560, without a sub), but it also died in August last year (review and early production samples do have a tendency to go pop with me), so I started using headsets, and just despised it. Don't get me wrong, you can get some seriously good headphones, and for some folk, that's fine, but I like to have my ears out, and obviously I'm sitting at a PC for a good portion of the day. So, very recently, I decided to take the plunge and buy a proper custom audio setup.

I'm actually running a set of active Audioengine A2+ Wireless satellite speakers, on Kanto 16-degree tilted stands (apparently, they help with the treble, because they points the tweeters up at your ears), and then have those plumbed in to a powered Cambridge Audio SX-120 70W subwoofer (bought the last one from Newegg) underneath as well. The A2+s are incredible really; fantastic mids and trebles, and they do put out fairly acceptable lower tones, too, though you really do need a subwoofer to round out the sound if you love music at lower volumes.

All in all, it came to around $587 for the lot (including stands), but I'm really impressed with the result. The satellites are just awesome little things. They're surprisingly potent, given their size, and they have connectivity for Bluetooth, USB, and analog audio as well. I tried USB first, but prefer analog myself. I kept having problems with it disconnecting from my motherboard for whatever reason. But hopefully, with the bigger investment, these should last a lot longer than one year. However, I hear good things about Audioengine's warranty, so I'm a little less worried.

Outside of Audioengine, Kanto also does a pretty nifty set of YU powered bookshelf speakers, in a similar design and size, and there's a few other brands out there, too (Edifier, for example, if you're looking for something more affordable). But I'd definitely recommend them over a soundbar if you want to let your ears breathe.

Game On!

Hi, I've been reading *Maximum PC* since the pandemic started and I'm a big fan of it so far. Do you have any plans on expanding your gaming coverage? I know it's not for everyone, but I enjoyed the article on the history of videogames and the look at virtual reality. Why don't you cover more of it?

–Aaron Matthews

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Hi Aaron, thanks for joining the team—we're actually seeing a lot of new faces around the *Maximum PC* community these days, and our subscriber numbers are up, too, so I'm very thankful for your continued support. It means the team and myself keep getting to do a job we love, and hopefully bring you all the content that you enjoy, too.

Speaking of content, gaming in particular is always something of a gray area for us. On the one hand, we have a lot of readers who are avid gamers and PC enthusiasts, while on the other hand, we have a considerable chunk of audience who aren't interested in it. Finding the right balance between all of that content and satisfying everyone's wants can be challenging.

As you mentioned, we have done a few more games-oriented pieces lately, with the return of Christian and his piece on gaming history, and Sam dabbling in VR, but it's not something we're looking to hit as hard as some other mags out there.

That said, next issue I've recruited Ian Evenden to write a small feature for us on the best and worst games of the last decade. It's a little different from our usual games features, admittedly, and there will still be three other features for folk less interested in those pixelated worlds, including a full-blown PC build feature (there will be two in that issue, actually), the ultimate backup guide, and an update on the latest in AI development.

Getting Started

Hi Zak, I'm a long-time fan; I've followed your work here and at Tom's Hardware for some time. It's my first time writing in. What got you into tech journalism? How do you get started? I'd love to play around with hardware all day, but don't know where to begin.

–Ricky Leung

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Oh wow, that's a big question, and I'm not sure I can fit my entire story into these pages, or how relevant it is. I sort of fell into tech journalism a little by accident. I really didn't know what to do with my career when I was growing up, and I failed a few exams. My dad asked me what I was good at, and I said computers and writing, so he told me to be a journalist. So, I re-sat some exams, went to college, and graduated with a solid degree in journalism. I then returned home, aged 22, and tried to get into daytime news, which was really difficult. I applied for 66 jobs over the course of a year, while working as a laborer on building sites with my dad, and offered myself for free to a ton of local papers, too, but no one would take me on. I nearly nailed a graduate scheme to work for Volkswagen in its PR department, got down to the last 10 candidates, but missed out, which would've been a very different route.

Then one of my friends found the listing for a staff writer at *Maximum PC*, shared it with me, and told me I'd be a perfect fit. I realized I'd been an idiot, as I was massively passionate about tech, but wasn't applying for jobs in the field. I applied, and six years later, here I still am.

If I were to give advice to someone starting out today who wants to join a big brand, you need to know that these jobs are very scarce, and you really need to specialize in a particular field (whether that's PCs, cell phones, cars, mountain biking, you name it). There's a ton of experienced applicants out there looking for work, too, so you've really got to make yourself stand out, and make sure you have proof of your writing, even if it's just your own blog. I also recommend tailoring your résumé and cover letter very specifically to each and every job you apply for. The biggest thing is passion, though; prove you want the job, and show you're passionate for the job, the brand, and the life, and it'll help a ton.

Getting to play with all this hardware, writing about it, interacting with readers and fans, and traveling the world (in more normal times) attending events is awesome, and I'm very privileged to be in this position. It's something I'm reminded of everyday.

THE BUILDS

THIS MONTH'S STREET PRICES...

ANOTHER MONTH, another depressing set of GPU prices across all the major online retailers. Even worse, it seems that prices of budget CPUs are rising, too, with AMD's Athlon 3000G rising by a small amount and Intel's i3-10100 leaping up by more than a third. It's dispiriting, but there aren't many good alternatives; if you're considering getting an i3 right now, the 10300 is only 30 or so dollars more than the 10100, and offers significantly better performance. There aren't really any good alternatives to the AMD chip, as we're seeing low stock on processors such as the Athlon 240GE.

Both our budget builds this month have new motherboards: Gigabyte's wallet-friendly offerings for AMD and Intel respectively, the B450M and B460M DS3H V2. They're straightforward mATX mobos, devoid of flashy but expensive RGB lighting or similar fancy features. They're also some of the most affordable boards available right now, so props to Gigabyte for making them an easy choice.

We've done something similar with the RAM for these two builds, too. These are both 2x 8GB kits from GeIL at 3,000MHz; GeIL isn't one of the big-name brands when it comes to memory, but you're ultimately often just paying for the same chips (from Hynix, Micron, and so on) with a different company name slapped on the side. The Evo Spear and Orion kits from GeIL are perfectly good components available for cheap, although we do admit that they're pretty ugly in comparison to memory from Corsair or Crucial.

There wasn't much else that needed changing in the budget builds, with prices rising subtly across the board but few opportunities to scrimp and save. We did swap out the SSD in our Intel build, opting for XPG's gaming-oriented Gammix S5 drive, which kept our costs steady without much change in performance. Samsung still has pretty much the only good PCIe 4.0 SSD in the 250GB range, so the AMD build doesn't get a new drive (although said Samsung SSD did drop by 20 bucks this month, which is nice).

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W EVGA BA 80+ Bronze	$35	
Mobo	Gigabyte B450M DS3H V2 NEW	$70	
CPU	AMD Athlon 3000G	$98	
GPU	AMD Radeon RX 6700 XT 12GB NO STOCK	$480	$900
RAM	16GB (2x 8GB) GeIL Orion @ 3,000MHz NEW	$77	
SSD	250GB Samsung 980 Pro M.2 PCIe 4.0	$70	
HDD	1TB WD Blue 1TB 7200	$45	
OS	Windows 10 Home 64-bit OEM	$32	

Approximate Price: $1,002 or $1,422

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	500W ARESGAME AVG500 80+ Bronze	$37	
Mobo	Gigabyte B460M DS3H V2 NEW	$97	
CPU	Intel Core i3-10100	$163	
GPU	Nvidia GeForce RTX 3060 12GB NO STOCK	$330	$930
RAM	16GB (2x 8GB) GeIL Evo Spear Phantom Gaming @ 3,000MHz NEW	$74	
SSD	256GB XPG Gammix S5 M.2 PCIe 3.0 NEW	$40	
HDD	1TB WD Blue 1TB 7200	$45	
OS	Windows 10 Home 64-bit OEM	$32	

Approximate Price: $913 or $1,513

IT'S TIME FOR a processor upgrade! The 3000-series Ryzen chips are becoming more scarce, to the point where a shiny AMD 5000-series CPU is starting to look like an excellent alternative. As such, we've gone for the Ryzen 5 5600X, which offers a performance boost in the range of 15 percent over the 3600X it replaces, all for a very modest rise in price. As it's far newer, too, this build is now more future-proof than ever. Mind you, a new AM5 mobo will likely be the order of the day once the next chipset generation for AMD lands next year.

The Intel system doesn't get any such upgrade (as it already has an 11th-gen Core processor) but it does get a new motherboard, the Z590M PRO4 from ASRock. At $180, it's reasonably priced for a Z590 mobo, and it comes with RGB lighting and a heat shield for your M.2 drive (although the Gigabyte Aorus M.2 SSD can be bought with its own chunky heatsink). We toyed with the idea of changing up the cooling solutions for these two machines, but found we were already getting the best value for money with our existing AIOs.

The Intel rig also gets new memory courtesy of Silicon Power, a Taiwanese company better known for its flash drives and card readers. The XPOWER Turbine memory is a solid proposition, though, at a sensible price, with performance that comfortably hits the industry standards. A broad gamut of user reviews indicate that Silicon Power's memory is no less long-lasting and effective than RAM from household-name brands, and you can upgrade to the RGB version of the Turbine kit for 10 bucks if you choose.

Back in the AMD mid-range build, we've got a new PSU and SSD. The power supply is from a range we've recommended before; Fractal Design's excellent Ion Gold model, also seen here at a higher wattage in the AMD turbo build. The drive is a newcomer; PNY has broken into the PCIe 4.0 SSD market with its XLR8 range of M.2 drives, of which we're using the CS3040. You can expect to see one of these XLR8 drives tested properly in an upcoming issue.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$151	
PSU	650W Fractal Design Ion Gold NEW	$85	
Mobo	MSI MPG X570 Gaming Plus	$170	
CPU	AMD Ryzen 5 5600X NEW	$300	
Cooler	240mm Cooler Master Masterliquid ML240L RGB	$70	
GPU	Nvidia GeForce RTX 3070 8GB NO STOCK	$500	$1,600
RAM	16GB (2x 8GB) Team T-Force Vulcan TUF @ 3,600MHz	$85	
SSD	500GB PNY XLR8 CS3040 M.2 PCIe 4.0 NEW	$100	
HDD	1TB WD Blue 1TB 7200	$45	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,538 or $2,638**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-O11-Dynamic	$151	
PSU	650W EVGA SuperNOVA 650 GA	$80	
Mobo	ASRock Z590M PRO4 NEW	$180	
CPU	Intel Core i7-11700K	$380	
Cooler	Enermax Liqmax III 240 RGB	$70	
GPU	AMD Radeon RX 6800 XT 16GB NO STOCK	$650	$1,550
RAM	16GB (2x 8GB) Silicon Power XPOWER Turbine @ 3,600MHz NEW	$93	
SSD	500GB Gigabyte Aorus M.2 PCIe 4.0	$95	
HDD	1TB WD Blue 1TB 7200	$45	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$1,776 or $2,676**	

SAD NEWS: The awesome Phanteks Enthoo Pro 2 is no longer on sale, so you'll have to pay the full retail price of $150 if you want the tempered glass model. We still think that's a pretty good deal, though, and the closed-window version is also available for $130. That said, you'll want the glass window to properly enjoy the software-controlled RGB lighting of the MSI MAG CoreLiquid 360R AIO cooler we've included in the Intel turbo build, a steal at $130.

Prices on our AMD system have been falling across the board (minus the GPU, obviously), so there were precious few meaningful changes to be made. We did nab a new motherboard, Gigabyte's X570 Aorus Elite Wi-Fi, and a new SSD. PCIe 4.0 drives are getting more affordable, with Corsair and Sabrent both releasing more wallet-friendly variants of their MP600 and Rocket 4 drives, but we've gone with Team Group's reliable Cardea Zero Z440 drive.

Our high-end Intel machine has seen a lot more changes. That MSI cooler isn't the only RGB lighting we'll be blinging up this system with, as we've got a 32GB kit of G.Skill's TridentZ RGB memory to further illuminate the guts of that Enthoo Pro 2. We've also got a new PSU, as EVGA's SuperNOVA 750 G5 is a third off; down from $150 to $100, making it a killer deal given EVGA's product quality.

The big shift here is the CPU. This turbo rig no longer lags a generation behind its mid-range counterpart, as we're finally upgrading to the Intel Core i9-11900K. Team Blue's new flagship chip is a powerhouse, and as the i9-10900K is no longer significantly cheaper than its successor, it made sense to make the leap.

The i9-11900K had a slow start, with software compatibility issues hindering performance against its predecessor, but it's now in a reasonably good place (about 10 percent above the 10900K in most tests) and offers PCIe 4.0 support. That means we're getting a new drive in both turbo systems. The Intel rig gets Seagate's slightly pricier 1TB FireCuda 520, stated to last for up to a whopping 5,600TB of writes. Unless you're doing some really insane file transfers on a daily basis, we can't see how it would ever give out on you.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$150	
PSU	750W Fractal Design Ion Gold 80+ Gold	$90	
Mobo	Gigabyte X570 Aorus Elite Wi-Fi NEW	$210	
CPU	AMD Ryzen 7 5800X	$424	
Cooler	Fractal Design Celsius S36 360mm	$120	
GPU	Nvidia GeForce RTX 3080 10GB NO STOCK	$700	$2,250
RAM	32GB (2x 16GB) Patriot Viper Steel DDR4 @ 3,600MHz	$153	
SSD	1TB Team T-Force Cardea Zero Z440 M.2 PCIe 4.0 NEW	$170	
HDD	6TB Western Digital Blue	$150	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$2,199 or $3,749**	

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$150	
PSU	750W EVGA SuperNOVA 750 G5 NEW	$100	
Mobo	MSI Z590 PRO WiFi	$220	
CPU	Intel Core i9-11900K NEW	$550	
Cooler	MSI MAG CoreLiquid 360R AIO NEW	$130	
GPU	AMD Radeon RX 6900 XT 16GB NO STOCK	$999	$2,200
RAM	32GB (2x 16GB) G.Skill TridentZ RGB @ 3,600MHz NEW	$180	
SSD	1TB Seagate FireCuda 520 M.2 PCIe 4.0 NEW	$190	
HDD	6TB Western Digital Blue	$150	
OS	Windows 10 Home 64-bit OEM	$32	
Approximate Price:		**$2,701 or $3,902**	

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus a Holiday issue following the December issue, by Future US, Inc., 11 West 42nd Street, 15th Floor, New York, NY 10036, USA. Website: www.futureus.com. Periodicals postage paid at New York, NY, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $30; Canada: US$30; Foreign: US$50. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 2024, Langhorne, PA 19047, USA. Future US, Inc. also publishes *MacLife*, and *PC Gamer*. Entire contents copyright 2021, Future US, Inc. All rights reserved. Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in *Maximum PC*. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of *Maximum PC*. Products named in the pages of *Maximum PC* are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.

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